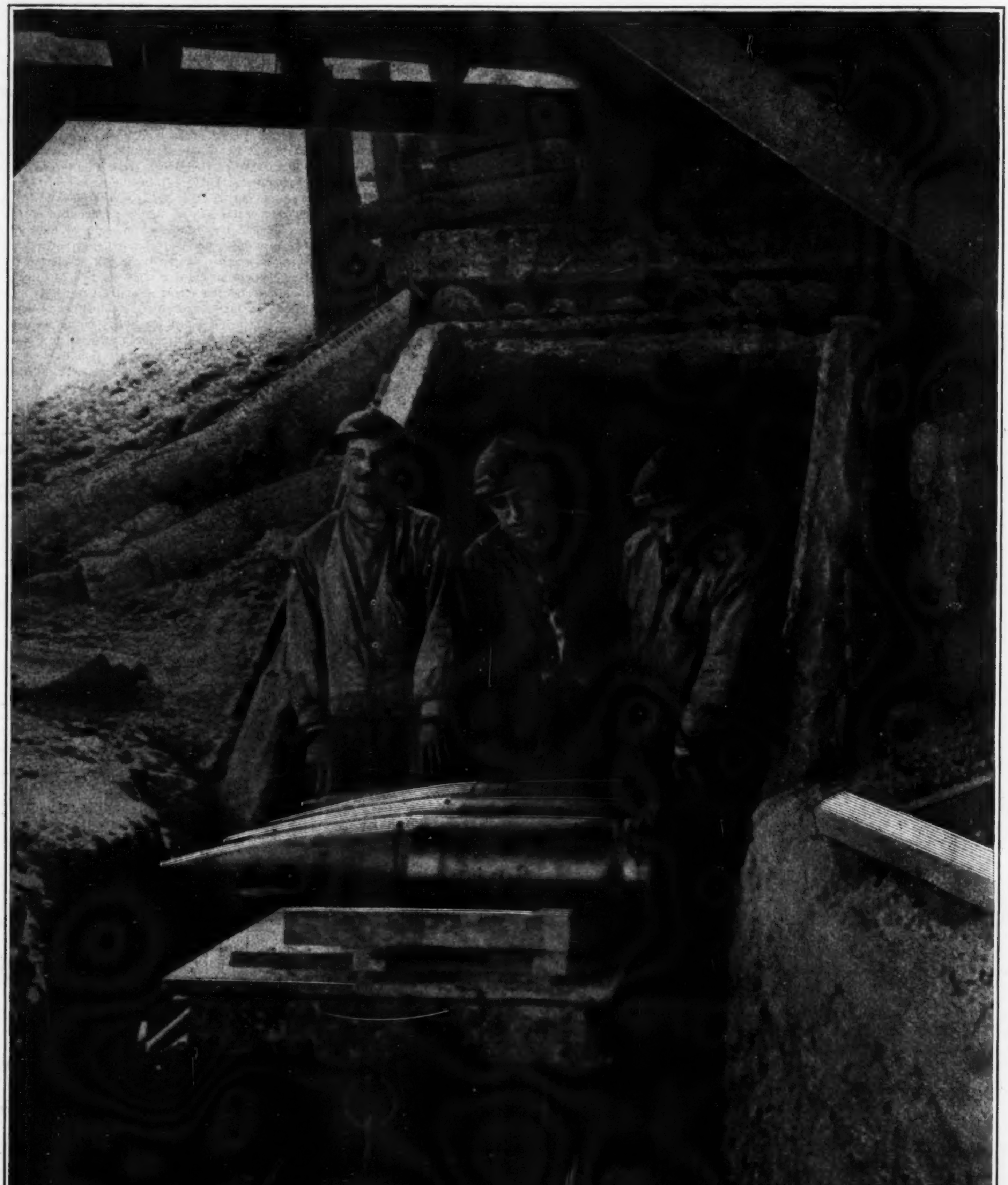
SCIENTIFIC AMERICAN SUPPLEMENT

VOLUME LXXXVI
NUMBER 2234

★ NEW YORK, OCTOBER 26, 1918 ★

Published weekly. Entered as second class matter, December 15, 1887, at the Post Office at New York, N. Y., under Act of March 3, 1879.

10 CENTS A COPY
$5.00 A YEAR



METHODS OF WARFARE THAT HAVE BECOME OBSOLETE

Elaborate trench communications as they existed a year ago

The Invasion of the Trenches by Rats—I

Its Causes and Its Remedies

One of the most repulsive annoyances which the men at the front have had to bear is the presence of a veritable plague of rats. Not only is the rat a disgusting beast and enormously destructive of food and clothing, but it is a carrier of various diseases, the most notable of which is the bubonic plague. The bite of the rat is also the point of departure of the several sorts of infection common in Japan, called the *Sokodu*[1]. The rat is also a favorite carrier for other microbes, such as the saccharomyces Tumafaciens and the Sporotrichum. Finally, the sewer rat has recently been accused of being a reservoir of the virus of the Icterohemorrhagic Spirochetose[2]. While the fear that the rats in the trenches might be the cause of epidemics has happily proved unfounded it is, nevertheless of great importance that this pest should be abated. The subject is discussed at great length in the "Revue Générale des Sciences" by Dr. P. Chavigny, a Surgeon in the French Army and an Associate Professor at Val-de-Grace. The following is an abstract of this important article:

When this trouble first became manifest in the trenches the French Service de Santé undertook to check it, but in spite of all efforts the rats continued to increase enormously. Dr. Chavigny attributes this to the fact that the authorities were obsessed with the idea of the rat as a microbe carrier, and, therefore, applied only to the Pasteur Institute for a remedy; whereas, in his opinion, the question is strictly one of Zoology, and it is to the authorities on rodents, and not to the bacteriologists that we must turn for relief. He tells an amusing story to the effect that one man in charge of a crew for exterminating rats on being asked what sort of rats he had to deal with, replied promptly: "With big rats, middle-sized rats and little rats." The fact is, the question must be studied from the point of view of the nature of the rat, its elementary habits, and its laws of reproduction. It is the prevailing ignorance of these questions which explains the prolific propagation of the rats at the front in spite of the hygienic measures taken against them.

HISTORY

It is a current notion in military hygiene that campaigning armies have always been subject to persecution by rats.

At the beginning of the campaign of 1914, the invasion of the trenches by rats was very rapid; however, there is nothing to support the view that these animals emigrated from some other locality. It seems on the contrary to have been due to the propagation of these animals on the spot with almost incredible rapidity. Many things bear witness to the fact that this multiplication began at the precise time when trench warfare began, at a date later therefore than September, 1914. It is worth noting that not only the French and British troops were annoyed by the rats, but the Italians also. In the latter case these animals were a special nuisance during the month when the troops were holding the trenches on the Carso at which period food was quite abundant. When the Italian troops retreated in September, 1917, and located themselves in territory to the rear, their rations were strictly limited, and at this time the rats almost completely disappeared.

In Morocco, where rats are commonly abundant in the native towns, and around the Government magazines, there has been no abnormal increase in the number of rats since 1814. They are almost unknown among marching troops or in movable camps. In block-houses or fixed posts rats make their appearance some four or five months after their erection (Dr. Colleye). These facts constitute manifest proof that the rat is a particular plague of armies in fixed posts (in the trenches or in case of siege).

LIMITS OF INVASION BY RATS IN THE REGION OF THE TRENCHES

Rats have bred to excess in all the regions towards the extreme front where large numbers of troops have been stationed and lodged under hygienic conditions hastily formulated; the zone of this excessive multiplication scarcely exceeds a band of territory some ten kilometers wide. Even in villages quite near the zone of the trenches, abandoned by the civil population, and occupied by troops, the rats have not appeared in very great numbers, because these villages have still retained some rudiments of the hygienic conveniences of the times of peace.

In villages which are entirely deserted rats are comparatively rare, even when quite near the trenches. It may be said in brief that rats have been the inseparable companions of the soldiers in the trenches, and that the area over which they extend reaches from the vicinity of the kitchens up to the first lines. In the village of Ancervillers, which was entirely evacuated, there was to be found not a single trace of the droppings of rats, though every house was carefully searched for this constant witness of their presence. On the other hand, in a single house in this territory the rolling kitchens of an Infantry Battalion had been installed. The cooks complained that this house was rendered absolutely uninhabitable by the number of rats living there; traces of them being abundant in every room in the house. This definite localization in a single house wherein the cooking department and the provisions were located is very significant. At some distance from Tahure an ambulance was installed on agricultural land, far from any dwelling house. At first not a single rat was to be seen, but a few days later they made their appearance and were seen as abundantly as elsewhere . . . It should be remembered that this extraordinary multiplication of the rats in the trenches in no wise corresponds to a general invasion of fields or towns by the rodents. In certain countries and in certain years rodents have multiplied excessively under the influence of causes not as yet fully known, and such invasions are only too well known in the country, where they have caused the destruction of crops. In 1904 for example, millions of hectars of farm and forest lands were ravaged by these rodents in the West of France. In 1911 a similar plague occurred near Soissons. In 1913 they appeared in the lower Charente and to a somewhat less degree in Normandy. In 1914, on the contrary, and during the following years, the number of field mice was almost normal. It should be observed that the multiplication of the rodents of the fields and forests has only an indirect connection with that of the rodents of the trenches, since these animals are absolutely distinct in species. The agricultural losses were caused by field mice, which never frequent human habitations. In those countries where the fields are ravaged by rats the distinction is easily made. An interesting idea in Epidemology concerning miliary fever confirms this idea of the distinct division of rats into town rats and country rats, several physicians having observed that the epidemic of miliary fever was stopped at the gates of cities, recalled that it was just here that the field mouse, to which they attributed an important role in the diffusion of the malady, also ceased to make his home[3].

However, these notions of the limited habitat of the various species of rodents in the family of the Muridae are not yet accepted by all authorities; thus Strickland[4] believes that the *Mus Decumanus* is particularly a country rat, while the *Mus Rattus* is a city or semi-domestic rat. This distinction is far from being accepted by most naturalists.

In the zone which lies in the vicinity of the trenches there is sometimes a multiplication of certain species of field rats; thus I observed in 1915 and 1916 an abnormal increase of the field rat (*Mus Sylvaticus*) in the neighborhood of Nancy. In the fields where the crops of the preceding year remained standing, the increase was almost unbelievable. In open daylight the surface of the ground appeared to be in motion, so formidable was the number of these rodents. Their incessant motion going and coming had created veritable paths and tunnels of beaten earth. No measure of destruction was taken against these rodents, yet they disappeared as rapidly as they had come. In fields which remained uncultivated they no longer found the food they needed, and in the summer of 1917 they had absolutely disappeared from these regions, which they had devastated in preceding years.

THE DIFFERENT SPECIES OF RATS IN THE TRENCHES

It is generally supposed that the black rat disappeared from Europe about the middle of the last century, driven out by a formidable competitor, the brown rat from the Caspian regions. However, the black rat has not entirely disappeared, though it has been forced to share its habitations in our dwellings with its brown rival. The black rat chooses the upper portion of houses and barns, since these are dry; the brown rat installs itself in damp locations, kitchens, cellars and vaults. It is very prolific in sewers and slaughter houses. Both these species cling to human habitations; when the latter is found at some distance from houses, it is because it has followed the line of a sewer, living on the garbage carried down. It is this brown rat which predominates above all in the trenches (*Mus Decumanus*) and (*Mus* or *Epimys Norvegicus*). Its specific characteristics are as follows: The fur of the back is reddish brown, the stomach white or light gray, the feet are flesh color and almost bare, the ears are one-third as long as the head, the tail is shorter than the body and ornamented with from two hundred to two hundred and ten rings. Finally the palate is warty. The Black rat (*Mus Rattus*) is found very exceptionally in the trenches when these happen to be dry. The fur of its back is a very deep gray, with almost black shadings (the soldiers have occasionally told me that they had seen and caught blue rats). The hair of the abdominal regions is of a deep ash color, the feet are blackish but the digits have scattered white hairs upon them. The ears are more than half as long as the head; the tail is longer than the body and bears from two hundred and fifty to two hundred and eighty rings. The transverse folds of the palate are smooth. The biology of these animals has usually been studied in specimens of the white rat, which is easily handled in captivity, while the black rat is very ferocious and the brown rat still more so. Furthermore, the two latter are usually sterile when caged. White rats seem to be merely an hereditary albino race, derived sometimes from the black rat and sometimes from the brown. The albino rats which I made use of for my laboratory experiments in 1917 belong to the latter species.

STUDY OF RATS IN CAPTIVITY

Both black and brown rats live long in captivity, provided they be given suitable and abundant food. The white rat readily breeds when caged. While the white rat is very tame when gently handled it retains its instincts of defence against enemies. I have seen one jump boldly at the muzzle of a dog which showed hostility.

The sense of smell is very slightly developed in the white rat, and the sense of sight appears to lend it no better aid in the search for food. The black and brown rat appear to have better vision than the white rat, especially in the dark. For example, when fleeing from danger, they instinctively find the mouths of their holes. Observation has revealed almost innumerable manifestations of amazing intelligence in the black and brown rat, especially with regard to the finding of food and the avoidance of danger. They are particularly clever in detecting the mechanism of a trap which holds them prisoners, and when a cake poisoned on one side is placed in their haunts, after the second or third time they turn it upside down and gnaw away the whole side that is not covered with poison. Among their means of defence when taken prisoner there is one which is highly original, the secret of which the white rat has retained. If one takes a rat by the end of the tail and holds it in this way suspended in the air, the animal begins to give its body a rapid whirling motion; the twisting of the tail thus produced soon causes it to break and the animal regains its liberty at the sacrifice of a few shreds of tendons.

The nocturnal habits of rats make them particularly annoying in the dugouts, where they prevent the men from sleeping. The night, by the way, is the best time for hunting and destroying them.

Rats show an almost incredible resistance to parasites. Thus in the case of the trypanosome, the rat exhibits no apparent disturbance of health, even when its blood is so infected with these that the parasites are as numerous as the red blood corpuscles. Further-

[1] L. Dessauvages: Disease from Rat Bite (Japonese Sokodu). *Th. Montpellier,* 1917.

[2] *Paris-Médical,* 1917, vol. xxiii, pp. 168 and 193.—Louis Martin and Auguste Pettit: Presence of *Spirochaeta icterohemorrhagiae* in the brown rats of the trenches. *C. R. Society of Biology,* Jan. 6, 1917.—Courmont and Durand: *Bulletin of Medical Society of the Hospitals,* Paris, Jan. 26, 1917.—It should be noted also that the rat harbors a bacillus closely akin to that of leprosy (Marchoux: *Presse Médicale,* 1914, p. 201).

[3] Chautemesse, Marchoux, and Haury: Miliary Fever and the Field Rat. *Bull. Acad. de Med.,* 1906, p. 293.

[4] Strickland: *Lancet,* Nov. 14, 1914.

more the white rat is almost useless in bacteriological laboratories since it is immune to the majority of pathogenic germs[5].

The white rat lives two or three years. Towards the end of life the females become a little less prolific, but the males retain their full reproductive powers to the last. It is probable though unproved that the black and brown rats have a similar longevity.

When well fed rats of different species live together in unity, provided they are of different sex, or that both are females. But two males will fight to the death. But a mouse placed in the cage of a brown rat is at once devoured. However, the two species often live together in the same house when both are at liberty.

FOOD

Both the black and the brown rat are strict commensals of man; and this close adaptation dominates the whole history of these creatures, conditioning their reproduction and their invasions. This fact, which has not received the attention it deserves, is of fundamental importance with regard to the struggle to eradicate them.

According to Lantz[6] the brown rat, which is nearly omnivorous, eats two ounces of food daily, the demi-adults requiring the same amounts as the adults. According to this authority a brown rat will consume 45 to 50 pounds of grain per year. It also devours poultry and eggs, game, vegetables, fruit, coffee, dates, oranges, cocoa; it gnaws vines, clothing, textiles, leather covered books, it is fond of glue and attacks harness, especially when worn, and curtains, whether of silk, cotton, or tapestry. This list of Lantz is both incomplete and inexact. Incomplete, because the rat attacks anything its teeth can take hold on, and inexact because, eating, gnawing and spoiling have been confounded; the rat, in fact, is a terrible spoiler, gnawing incessantly and indiscriminately any object its teeth can make an impression on.

The marked identity of *menu* in the food of men and of rats is curious enough between two species whose dental type is so different. But the rat differs from man in the absolute necessity it is subject to of eating often and enormously. The rat speedily dies of starvation. For example, a rat previously supplied with abundant food was placed in a cage on May 16, without food or water. It roved restlessly and anxiously around. At noon on May 18 it appeared as lively as ever. At 3 o'clock the same day it appeared feeble, and at five it was dead. The same day another was caged without food but with plenty of water. It drank with avidity, nevertheless it died likewise on May 18 at 3 P. M. quite suddenly. Obviously starvation was the cause of the rapid death in these two experiments.

According to Lantz an adult brown rat devours 57 grams of food daily. The average weight being 140 grams, the ratio of daily food=1 to 2.4. If an adult man required the same proportion he would need 33 kg. (72.6 lb.) of nourishment per day. These figures represent an almost unbelievable intensity of digestion. I consider them somewhat exaggerated, since I have been able to keep brown rats in good condition on a daily ration of 30 to 40 grams, though even that is a pretty high coefficient of nutrition.

It is this need of abundant nourishment which makes cannibals of rats. Some soldiers experimented with rats, putting eight in a cage together. Eight days later only one was there and it was seriously wounded.

However a precise statement of the alimentary regimen of rats is more difficult than it would appear, since individuals vary in their tastes. Experiments made by myself, in collaboration with Dr. Laurens, prove that, contrary to accepted opinion, the brown rat has a very restricted diet, being comparatively fastidious. Thus it eats the crumb but not the crust of bread, unless urged by extreme hunger. Some rats actually died with crusts still in their larder. Both black and brown rats like cooked rice, potatoes, carrots, and fish, as well as cheese and certain uncooked fruits and salads. They will devour the flesh of a melon but leave the rind. They like lard pastry, sugar and chocolate[7], as well as meat (principally cooked), though the latter seems scarcely consonant with their dentition. They sometimes eat raw meat, but this is by necessity and not by choice.

[5] The *Saccharomyces trimefaciens* and the Sporotrichum are exceptions.

[6] Lantz: Rats in the United States. Wash., 1909.

[7] In a storehouse of canned goods rats ate the gummed labels off of the tin. In greenhouses rats do much damage by gnawing flower bulbs; it is not precisely known which they eat and which they only destroy, except that they never touch certain kinds of narcissus.

They neglect turnips, radishes and dandelion; they will eat oats but will perish if confined to this food. When tainted meat is given them they eat only the sound portions. They will not touch barley.

A rat fed only on fruit will die of starvation in a few days. If fed only on those stuffs which it eagerly gnaws, cloth, leather, wood, etc., it dies as soon as if entirely deprived of food. Experiment proved, rather to our astonishment, that the rat is not graminivorous; it eats wheat only in default of other food. The trenches abound with tales of the rat's greed for soap and candle, but when these were placed in their cages they were eaten only in default of other food. The alimentary canal of the rat is too similar to that of man for it to find nourishment in human fecal matter, as has been supposed. The rat is known to attack cadavers, but this is by necessity rather than choice.

One cause of the rat's addiction to man's diet is that it neither hibernates nor lays up stores for winter, as do other rodents, the marmot and the squirrel, respectively.

In the interests of prophylaxis efforts have been made to denature kitchen garbage with some substance which would make it obnoxious to rats. Such a substance may exist, but has not yet been found. Rats will eat with avidity their ordinary food though drenched with cresyl or gasolene. However, they seem to feel a distaste for food sprinkled with carbonate or hyposulphite of soda. Mandoul, indeed, concludes, from experiment, that gasolene drives rats away without poisoning them[8]. But gasolene is too valuable in modern warfare to be employed for this purpose.

Rats are not only voracious but they defile food. If they devour nearly three times their weight of food, they destroy two or three times as much. Whenever they find a fragment of food not too heavy for them to carry they drag it near their holes, eat a part, and soil the rest with urine[9]. This behavior is very remarkable in caged animals. When they are given, by way of experiment, limited and insufficient rations they spoil half of it, covering it with excrement and thus dying of starvation with food which they have destroyed beside them. In captivity, they always foul even their drinking water with their droppings.

The brown rat is a skilled digger, and this forgotten ancestral habit is revived in the trenches when insufficient shelter is present, but this labor is undertaken only when some convenient hole or crevice is lacking.

Whenever such rat runs were opened I found that they led to a central chamber lying at a depth of 0.7 m. to 1 m. and about 0.2 m. in diam. Two or three tunnels usually lead from this chamber, whose main use is to enable the mother to protect her litter from the voracity of their father and other males.

REPRODUCTION

As I have said, the black and brown rats are usually sterile in captivity, but figures furnished me by soldiers and "deratting" crews indicate that the litter numbers from 8 to 12. These figures agree with those of Lantz, who gives the average as 8.1, based on 12,000 observations. A female white rat is delivered at the end of 21 days, and is soon ready to be bred to the male once more. Sixty-two days was the minimum time between litters noted in my experiments. The young females are ready to breed at from two and one half to three months of age. The first litter commonly numbers only 5 or 6, but the second contains 10 or 12. Unlike the rodents the young are very strong and healthy.

Lantz makes the amazing estimate that the progeny of a single couple, if undestroyed, would number 20 millions in three years, and this number is even below the theoretic figures.

Young white rats weigh about 2 gr. at birth and their length is 2 cm., not including tail. Thus a female weighing 150 gr. may give birth to a litter weighing 50 gr., not including the weight of the placenta. The young are suckled for some 20 days and during this time the mother usually changes her nest once. Strange to say the old nest is never found soiled with the excrement or urine of the young. Surprised by this I made a minute examination and discovered that between feedings the mother nimbly turns over each young rat and licks clean its ano-genital region, apparently swallowing all excreted matter. This proceeding so astonished me that I almost doubted my own eyesight till I accidentally came across the mention of an identical habit in rabbits in Féré's work "*The Sexual Instinct*" (p. 66). Furthermore zoologists are very familiar with such behavior.

Cold has a marked influence on the pullulation of rats.

[8] H. Mandoul: *Arch. de Parasitologie,* 1909, p. 451.

[9] The same thing is true of domesticated rabbits, which spoil just as much food as they eat.

The brown rat has spread throughout the world, but is never found in cold countries. Moreover, in our own climate reproduction is absolutely inhibited in the winter, providing the cold is sufficiently severe.

An experiment by Masse and Gscheidler proves that the reproductive period is the time when the animals are most susceptible to destructive agents. They rendered a female white rat temporarily sterile by the injection of 15 drops of one per cent solution of morphine.

Lack of food as well as cold and intoxication interferes with reproduction. I experimented with a female weighing 190 grams at the beginning of the experiment. Instead of the 40 grams of her usual daily ration she was kept on a strict diet of only 25 grams, the amount required for an animal weighing 175 gr. She retained perfect health and liveliness but failed to bear young during a period of three months though repeatedly bred to a healthy male. Yet when fed normally she had had litters at the usual interval after a single breeding, one of these numbering eleven. There is nothing surprising in this. It is a general rule in biology for it has been proved to hold true even in plants. Naudin, L. Blaringhem and Bordage made the observation that even the sex of flowers depends upon the intensity of the nutrition. Thus the male sex in the progeny indicates enfeebled nutrition in the parent plant. It is evident, therefore, that the percentage of nutrition is the controlling factor in the spread of rats in any region. The rat has few enemies capable of destroying it in the adult state, and my researches with reference to destruction, in the second part of this article will indicate how difficult it is to prevail over the vitality, courage, and malice of adult rats. In every part of the world apparently their multiplication is governed by the amount of food available for the females. Thus at the beginning of the war the rats multiplied enormously in the trenches because of the concentration of population, the lack of sewers and the profusion of garbage.

(*To be continued*)

Chloropicrin

By Maj. Orland Russell Sweeney,
C. W S., U. S. A.

Chloropicrin (Vomiting Gas) was prepared by Sthenhouse as early as 1848. The method he employed was to treat a solution of picric acid with bleaching powder; and, while there are a number of other ways of preparing it, this original method is the one used in preparing it on a large scale.

Chloropicrin, like many of the other so-called war gases, is a high boiling liquid. It is generally used in mixtures with other "gases," and, because of its high boiling point it is nearly always used in artillery shells or bombs.

It penetrates the masks and respirators more readily than most other gases and produces nausea or vomiting, thus forcing the removal of the masks. It is an active lachrymator and is used for this effect also. There are records of it having been combined with chlorine and used in cloud attacks. It is a violent poison, in high concentrations it causes blindness, and in extremely slight concentrations it is very painful in its effect on the eyes.

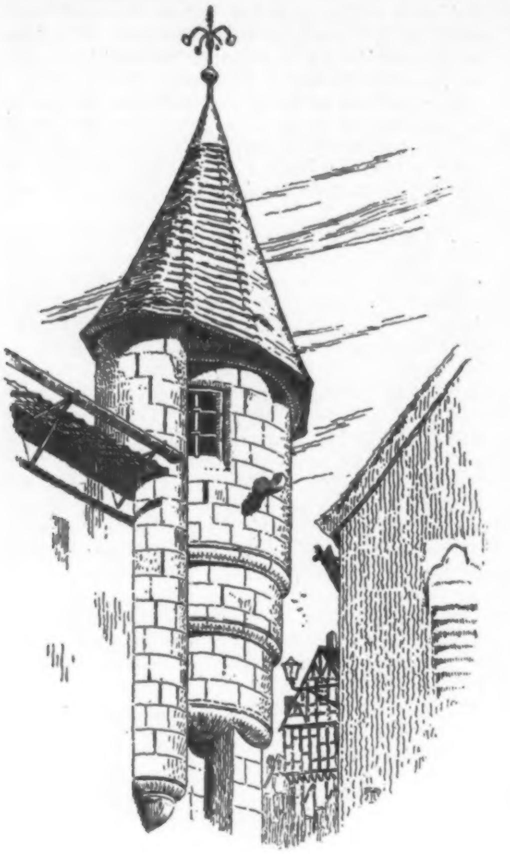
In direct contact it produces painful, slow-healing burns, and deep abscesses. It is an exceedingly stable substance being only slightly attacked by water, chlorinating agents, sodalime and many other active chemical reagents. It is this property which makes it so difficult to absorb in the mask; in fact, it is only mechanically absorbed by the charcoal in the mask, and is not affected by the chemicals at all. It is a remarkable fact that such a chemically inert substance should be so toxic. Most substances gain this property by virtue of their great avidity.

Its high boiling point makes it a valuable substance to scatter about since it soaks into the ground and persists for a long time. On the other hand it is volatile enough to keep the "strata of air" above it thoroughly poisoned.

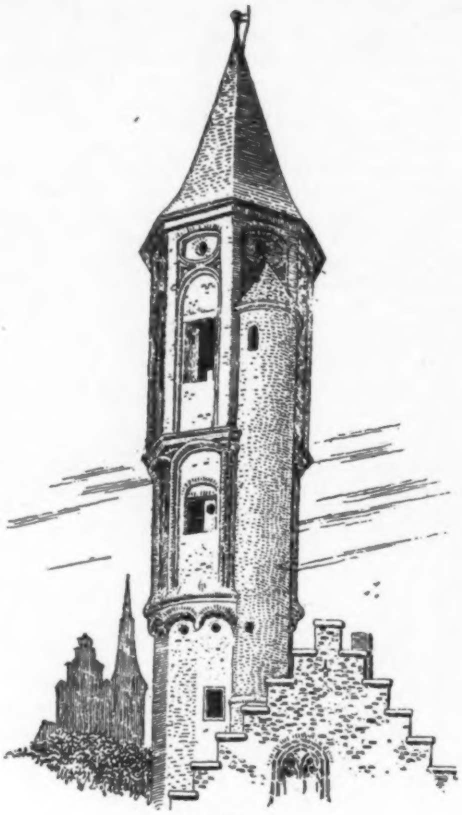
It has been used by both the Germans and the Allies. At the present time the United States probably is producing more than any other country.

While the machinery employed in the manufacture of chloropicrin differs greatly in the various countries, it is all designed to bring about a mixing of chloride of lime and picric acid. After these substances are mixed the "gas" is separated by distilling it out of the reaction mixture.

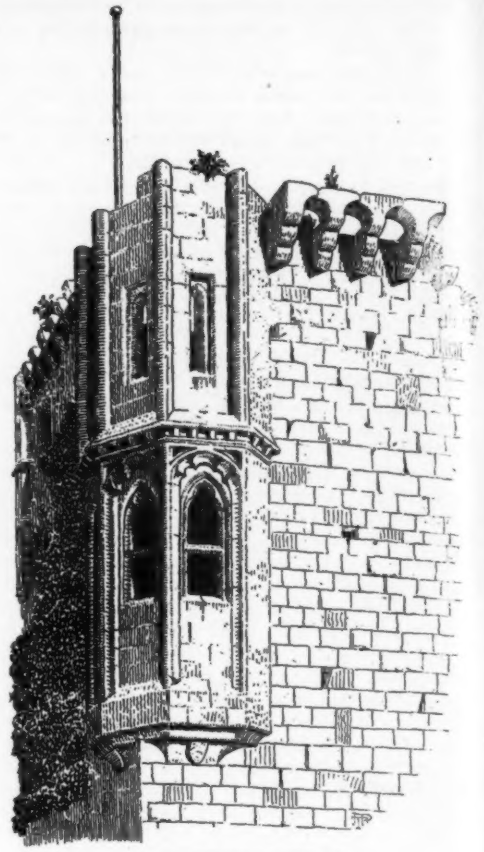
Prior to the war chloropicrin never had a use, and it was prepared only for scientific study. Recently, however, it has been used as an insecticide, and it may become a valuable adjunct to agriculture.—*From the Chemical Warfare.*



NEVERS



BRUGES.



ASHBY-DE-LA-ZOUCH.

Gazebos*

A Curious Feature of Ancient Architecture

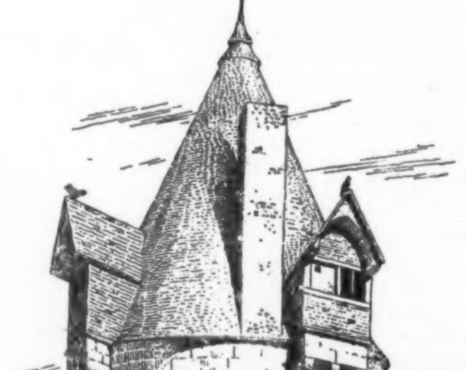
By the Late J. Tavenor Perry

No name could be more descriptive than gazebo for a building, whether it assume the form of a tower or balcony, which was erected for the purpose of enabling anyone to gaze about; and there is no need to hunt through the pages of a dictionary for the origin of so obvious a term. Curiosity is common to the race, and contrivances of all kinds have been called for throughout the ages, and will continue to be, to enable people to pry into their neighbors' affairs; and architectural solutions of the problem must always be as interesting as they have frequently proved most picturesque.

Doubtless in the remotest antiquity such means of prying were in vogue, and the hanging gardens of Babylon may have presented replicas of the towers of Kent or Chambers; but we will go no further back for examples than Pliny's villa at Laurentinum. The Plinys, as we know, were of a very inquiring turn of mind, and are most appropriately commemorated at Como, their supposed birthplace, on the west front of the cathedral, by a sculptured representation of each engaged in looking out of a window. Thus it was that when Pliny the Younger built his celebrated villa he gave it two towers, and as they could be used neither for defense in such a place nor for smoking-rooms at such a period, we can only suppose them to have been erected to serve as gazebos where he could look into the grounds of his neighbors and watch their incomings and outgoings.

The formal gardens of the Renaissance period, as depicted on the engraved drawings of Kip, Kniff, and others, had their mounds and lofty summer-houses whence the surrounding country could be surveyed; but towers became a very marked feature in the later English gardens designed by Kent and his followers, who, as the Quarterly Reviewer says, in dealing with their work destroyed the terraces and ejected the statues of their forerunners, but "had temples, obelisks, and gazebos of every description" stuck about in the parks. And it was not only in England that these towers were found, for most people may remember the one standing in Marie Antoinette's Swiss farm of the Little Trianon, of which Laborde in his history of Versailles writes: 'Cette fabrique de mauvais goût par sa petitesse et par son invraisemblance était un tribut qu'il fallait à la mode du temps. Il y avait dans presque tous les jardins, d'obligation, une tour de Marlbrook." And this tower has been built in a sort of Moorish style, and may bear some fancied likeness to that from which "Sister Anne" watched for the coming of Bluebeard.

During the Middle Ages gazebos were a very important consideration in military architecture, and their variety in form and arrangement was infinite. Under the title of échauguette, Viollet-le-Duc gives a great number of these of a most dodgy character, providing at once facilities for looking out and protection for keeping out objectionable missiles, and in the castles of our own country many similar contrivances can be found. One example, from the half-destroyed keep of Ashby-de-la-Zouch will suffice, which is of an extremely beautiful kind, and shows how the occupant of its little chamber was placed in a position not only to observe what went on within the walls of the castle, but to scan the country beyond.

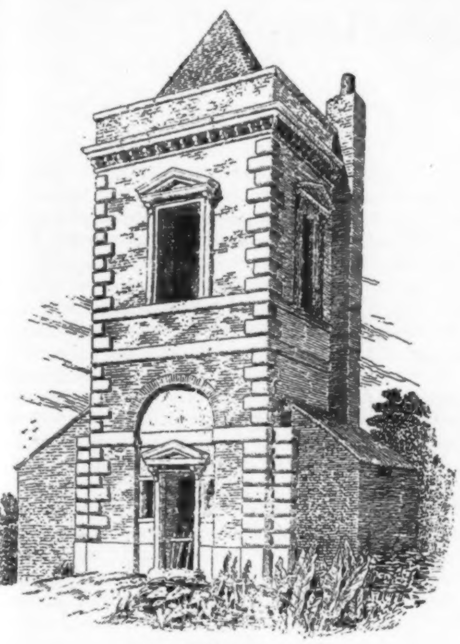


ORLEANS.

But these military examples are all more or less of a utilitarian character, and are much less interesting than those erected merely to satisfy pure curiosity; and of the transference of the military forms to domestic use we have numerous and picturesque examples in the cities of Northern France, of which we give two specimens. These are from Orleans and Nevers. The former of these is rather an adaptation of an older tower which has had dormer windows corbelled out from its roof on three sides, which give good views down main streets; while the latter is a fair representative of a type very common in Nevers and other French towns. The very interesting svelte tourelle of the Guild of St. Sebastian at Bruges served the purpose of watching the flying arrows of the bowmen, and it gives a very fine view over the city. It is generally believed to have been built as late as 1685, and if this be the case, and it has not been controverted, it is a remarkable survival of Gothic forms in the end of the seventeenth century. Not only Bruges, but all the towns of the Low Countries are full of turrets of a similar character; while the bartizan, such as the one we have given from Ashby-de-la-Zouch, was a common feature at the angles of all great towers, like the belfries of Bruges and Sluys.

But all of those examples belong to a dead and buried past, interesting for their artistic and archæological value, but impossible of imitation under modern conditions, and it is with examples nearer our own time that we are most concerned. In these days, when the laying out of gardens and garden cities is occupying so much attention, the picturesque gazebo may be again used, as well as summer-houses, pergolas, and other adjuncts of the terraced garden. Many suggestions may be found in seventeenth and eighteenth century work for the successful treatment of this feature, but there are two modes, which once had a great vogue, to be avoided; neither by sham ruins nor by Chinese pagodas lies the way to success. Yet both of these methods were employed by Sir William Chambers in laying out Kew Gardens; and much of this work still remains to astonish the present generation, chief of which is his great

* From *The Architect.*



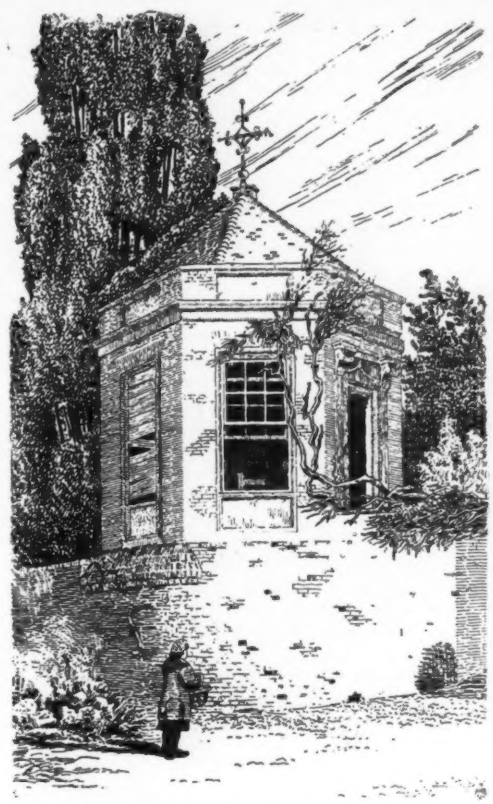
ISLEWORTH.

gazebo so widely known as the Kew Gardens Pagoda. These Chinese towers were extremely fashionable in the eighteenth century, and there was one standing on a bridge across the ornamental water in St. James' Park; while in 1752 Halfpenny produced a book of engravings among which were new designs for "A Chinese tower or gazebo." But the sham ruins are even greater favorites than the Oriental productions, as they could be made more realistic or useful, as at Chelsea, where Holland constructed an ice-house out of the stonework of Wolsey's Palace at Esher, or the ruins of Virginia Water, produced by ancient columns and marble work from Corinth, which George IV. had obtained from the British Museum; and as an example of this sort of work we give the gazebo still standing at Gunnersbury House.

There are two classes of gazebos, examples of which are still numerous in the neighborhood of London, although yearly they are getting fewer from dilapidation or absorption in so-called improvements, which might well be taken as types for reproduction in larger gardens which are being laid out throughout the country, or even in garden cities where the inhabitants have many if not all things in common. These are, first, the summer-house-looking erections raised high on the outside of enclosure walls of house gardens, generally on the edges of public roads or streams, commanding views of all the passing traffic; and, second, structures of two or three stories in height, the upper ones not only giving extensive views over the surrounding country, but often fitted up as banqueting rooms for summer revels. Of the first class numerous examples will occur to everyone using the main roads out of London, from the modest little shanty that is just visible over the garden wall to the great and often ugly structures that overhang the public way, like the great thing which stands nearly in front of the gates to Sion House. Such buildings are also frequently raised by the side of a river, when the gardens abut on one, as in the garden house at Hampton Court, and by the Thames side, as at Richmond; and we give a very pretty example of one now left neglected and fast hastening to dissolution. This is to be found, after some search among wharves and backyards, on the towing path of the canal at Brentford, but was built long before that was made. Then what is now canal was the principal branch of the river Brent, looking across the delta of the river, now hollowed out into a dock for the Great Western Railways, but then beautifully wooded and known—who can say why?—as Old England. It is a seventeenth-century structure, octagonal on plan, of red brick with somewhat elaborate woodwork, and its windows commanded fine views looking up the river into Sion Park or down the river over the Thames to Kew. It is sad to say that although our sketch was made less than ten years ago the windows and most of the roof have since disappeared, and before another ten have passed it will become an undistinguishable ruin among its squalid surroundings.

Of the more ambitious or towered kind of gazebo we give an example, also from the banks of the Brent, and like the last named already fallen into ruin and left to neglect and dissolution. Of its history nothing seems to be known, and although standing on high ground and very prominent as seen from the main western road, is quite without mention in the books. It seems to be an eighteenth-century structure in two stories, the upper one apparently approached by a wide newel staircase at the back which has fallen down, and the chamber on that floor, which appears to have been decorated with paintings, seems to have been intended to be used as a banqueting room. Of this class of gazebo numerous examples might be quoted. There were two such on the river front of the gardens of Beaufort House, Chelsea, and Walpole had one such to his Chelsea House by the Physic Garden, which he used for the entertainment of his friends; and this was the sort of gazebo which Marie Antoinette had built in her Versailles garden, to which we have already referred, and which the French called a "Tour de Marlbrook."

There is another tower of the same sort which, however unpleasant may be its associations, must be mentioned here properly to round off the subject, though it has no claim to our attention either for its picturesqueness or its architectural beauty; and as examples of such we give two of the grim gazebos which dominate the walls of Wormwood Scrubbs Prison.



A GAZEBO, BOAR'S HEAD YARD, BRENTFORD.

GUNNERSBURY.

WORMWOOD SCRUBBS.

Standardization of Freight Cars and Locomotives

It has long been admitted that the standardization of the engines and freight cars in use on the American railroads was highly desirable, but not until governmental control became a fact has it been possible to secure an effective agreement as to which types of cars and engines should be adopted. It is said that 2,023 different styles of freight cars and almost as many different descriptions of locomotives were included in the equipment of American railroads prior to the war. The facts are not known, but nearly every important railroad had its own specifications for cars and engines. None of these was identical, and they were generally changed in some detail when new orders were placed. There were box cars of both steel and wood, gondola cars, flat cars, hopper cars, refrigerator cars, tank cars, automobile cars, furniture cars, cattle cars, and many other sorts of cars suited to the different varieties of traffic. The lack of standardization increased the difficulties of repair when these cars were off the lines of the roads which owned them. Parts were not interchangeable and often had to be telegraphed for.

In a general way the same thing was true of the locomotives in use. Complete standardization will of course be impossible until the rolling stock and engines now in use shall have been entirely replaced by standardized types. Progress has, however, been made. Some 12 standard types for freight cars have thus far been agreed upon, and it has also been decided that hereafter only six types of locomotives of two weights each shall be purchased. The parts of these various types of locomotives and freight cars will be interchangeable. Their construction will be uniform and when repairs are needed they can be made with the greatest possible promptitude.—*Report of Director General McAdoo.*

Chemically Treated Fabrics for Powder Bags

Chemically treated cotton cloth, as a substitute for silk, is being tested out by the Ordnance Department. If found practicable for ordnance uses, the discovery will effect the double result of meeting a serious shortage in silk, and of bringing about a money saving in the ordnance program estimated at between $25,000,000 and $35,000,000.

Preliminary tests already made at the Aberdeen Proving Grounds have encouraged the department to proceed further with its experiments; and for this purpose an order for 5,000 yards of the new material has been placed with the concern responsible for developing the process of treating the cotton cloth.

At present millions of yards of silk are required in making the bags which contain the large powder charges used in the firing of heavy artillery.

Heretofore silk has been depended upon for these bags for the reason that no other cloth material has been found that would meet the peculiar conditions required. It is essential that not a particle of the bag container shall remain after the gun is fired. Otherwise a smouldering piece of the fabric might cause a premature explosion when a new charge was inserted.—*Chem. & Met. Engineering.*

Metals Used in Aeroplane Construction*

Their Composition and General Characteristics

By Walter J. May

At the present moment the question of greatest importance is how to make the most of what is usually available, and to this end not only has the composition of the metals to be considered, but the treatment to which they are subjected has to be carefully supervised. It is quite possible to take a really strong alloy when properly cast, and by some wrong treatment make it weaker than what is normally a weak alloy, yet this kind of thing is often done. Overheating in either foundry or forge will ruin most metals, and in the foundry "stewing" metals will cause both mechanical and chemical changes of a character not conducive to strength or durability. The temperature at which molten metal is poured is also of considerable importance, because improper temperatures ruin the strength of otherwise good metals, and not infrequently provide the causes of porous and faint run castings. A "burnt" or a porous casting lacks strength, while a faint run one very often cannot be used because it lacks some part which is an essential, although usually the strength is good enough. As a general thing, most metals and alloys are in the best state for pouring soon after the melting point is reached, but there are a few exceptions.

Sand moulding is largely used for castings, while a smaller amount of metal moulds are used for die-casting, and in some qualities of brass and some other metals hot pressing or "forging" is adopted, and, assuming that this is well done, it provides sound homogeneous articles which require little machining. Forging is, of course, done in the ordinary way, but welding has to be done by acetylene in more than a few cases, as fire heat is not always a convenient medium. In all cases machining is easy to anyone able to provide the right speed of cut, but filing and grinding are not easy at all times. Mechanical manipulation in all cases will need more or less skill, the better worker getting the more successful results.

In glancing through the metals used it will be found that aluminum has a somewhat prominent place, sometimes being used in its commercially pure form, but more largely as a large part of many alloys, such as aluminum bronze, or with a percentage of zinc or copper used to strengthen the aluminum, up to about 10 per cent. of the other metal being alloyed with the aluminum. It may be taken with copper and zinc that if from 7 per cent. to 10 per cent. be added to aluminum the alloy will be much stronger than the original metal, while it will roll well under proper working conditions; but if you reverse the percentages you will get a hard yet strong alloy, which will not roll or draw except under special conditions of temperature, while even then the results will be influenced largely by the actual content of the metal. On the other hand, 7 per cent. aluminum added to nickel makes a good alloy for many purposes, and from 7 per cent. to approximately 10 per cent. nickel added to aluminum makes a strong workable alloy of much strength provided the metals are pure. Of course, what is known as aluminum-bronze is copper plus from 5 per cent. to about 8 per cent. aluminum, and cast at a proper heat this is both strong and very workable, but it has to be made by a good workman from commercially pure metals to get the best results. Tin should not be added to aluminum or its alloys, but zinc often adds to their strength and mechanical value. Generally, however, the various aluminum alloys as used for light engineering purposes are chiefly specially devised alloys, like the complex and useful duralumin, which is composed of aluminum, copper, magnesium, and manganese, and which cannot, of course, be made at present; magnalium, which is an alloy of aluminum and magnesium; and possibly the alloy used for the framework of some of the German dirigibles, which is composed of 91.92 per cent. aluminum, 4.13 per cent. copper, 3.27 per cent. iron, and 0.67 per cent. silicon, with its high tensile strength of 40,000 lbs. per sq. in. and great stiffness. This last is not hard to make when you know how to alloy copper and iron together, but it may very well puzzle most foundrymen who have done nothing outside the ordinary run of commercial alloys. In all cases where aluminum forms part of an alloy it is not well to forget that the metal has reducing effects on various substances, and that, for instance, you may find silicon in an alloy on analysis where this element has not been added purposely, the aluminum having reduced it from the walls of the crucible. In the German alloy last mentioned it is well to note that both iron and copper absorbs silicon, and as the iron and copper alloy is probably made from carbon-free metals, the work of alloying would probably be done in clay or silica crucibles from which the aluminum might very well reduce the silicon to a large extent, and in such case the silicon content would be accidental as only 10¾ ozs. per 100 lbs. of alloy would be present, or the silicon might be added purposely by using silicon-copper in making the alloy.

Copper is used chiefly as parts of alloys, but to some small extent in an unmixed state for small tubes, wire, and electrical connections. Very little use is made of hardening, except by means of the addition of other metals as an alloy, but for electrical purposes some little attention might very well be given to copper hardened by chemical processes, by which a hardness sufficient for chipping chisels for brass and gun-metal, or for pocket-knife blades, can be secured. The writer is not "talking through his hat" in regard to this, because he made such things successfully years ago, and other persons can do the same—if they like. Tin is used as a coating to protect iron and other metals, in soldering, and as part of various alloys, but probably in regard to aeroplane work its largest use is for anti-friction or Babbitt metal, as when alloyed with antimony it can be made very hard, and, plus copper, forms the base of most of the successful "white metals" used for lining bearings. Zinc is used chiefly as part of the various brasses of different grades, but occasionally a small amount of sheet zinc is wanted, this having to be of good quality and toughness.

Antimony is used as a hardener for lining metals, its peculiar qualities making it especially useful in this way. Various proportions in combination with tin and copper are used generally, and according to the skill with which the alloying is done the results are secured.

Nickel is used as a plating metal for protective purprotective purposes, as a component in alloys, such as nickel or "German" silver, and in monel-metal, in conjunction with copper and iron. Its weight tells against any very extensive use, but its strength is a valuable factor which cannot be overlooked, and, rolled into thin sheets, it possesses advantages worth consideration in regard to many purposes.

Silver is used for electro-plating purposes only, but it has some advantages over nickel for some uses, for which reason it cannot well be overlooked.

Alloys form the bulk of the non-ferrous material used, however, and many alloys used are covered by patents, while all of them depend on their usefulness through the skill in which they are made and afterwards treated. Chief among the alloys at present used for constructional work are the aluminum alloys previously referred to and the bronzes or copper-tin and brasses or copper-zinc alloys, these being simple or complex, according to the ideas of the operator; and often alloys vary very much in strength, although the analytical results may give similar compositions. Heat treatment, minute differences in content, different methods of casting, and other small details make a lot of alteration in test results, and often a small departure from the regular practice of working will make several hundred pounds difference in tensile strength. No alloy made with scrap metal can be depended on for strength, whether the scrap is from private or Government supplies, and, taken all round, aeroplane alloys should always be made from new ingot metal, and not scrap ingots, as is so often used. Where compressive and not tensile stresses are applied, scrap metal alloys can to some extent be used, no doubt, but even then one must not depend entirely on the results shown by test-bars, unless they approximate in shape to, or are cut from, the body of the casting which has to actually resist the stress to be imposed. This cannot be too strongly insisted on, because the ordinary test-bar does not give actual strength under all conditions, but simply gives the comparative strengths of a series of test-bars only. No doubt these form very valuable guides to the worker using the alloys, but they are not absolute under all conditions, although they appear to be *the* fetish which forms the sole guide of many designers. Test-bar results are good for giving a general idea of the strength of a metal under its best conditions only, and cannot be depended on beyond this. Usually the simpler bronzes, such as gunmetal (Cu. 88 per cent., Sn. 10 per cent., Zn. 2 per cent.), simple bronze, (Cu. 90 per cent., Sn. 10 per cent.), phosphor bronze (Cu. 91 per cent., Sn. 8.5 per cent., Ph. 0.5 per cent.), and aluminum bronze (Cu. 92 per cent., Al. 8 per cent.) are the ones most used in the bronze section, as, properly made and manipulated, they cover all requirements in so far that with small alterations in their content they cover all the possible gradations of strength which this class of alloys will give. Brasses are variable according to the purpose they are used for, soft brass (Cu. 70 per cent., Zn. 29 per cent., Sn. 1 per cent.), hard brass (Cu. 66.6 per cent., Zn. 33.3 per cent.), manganese brass (Cu. 58.5 per cent., Sn. 0.5 per cent., Zn. 39.3 per cent., Al. 0.5 per cent., Mn. 0.2 per cent., Fe. 1 per cent.), and some other forms being used, while, of course, there are specialized forms of these alloys for extrusion, drawing, and other purposes. The strength of brass as well as its hardness is very variable, and for this reason considerable care is necessary in using the alloy most suited to the purpose in hand. In cases where the metals have to be electro-plated no aluminum can form part of the alloy, but otherwise this metal is sometimes useful in the way of producing bright, clean castings, and also in securing the even distribution of any small percentage of iron that may be present either by accident or design, iron often being added on account of its effect in causing the alloys to resist corrosion from exposure. Aluminum brass is used for die-castings to some extent and holds somewhere about 8 per cent. Al., but is subject to some little variation, as the total content sometimes differs sufficiently to make this necessary.

The softer alloys are principally those used for bearings in the way of "Magnolia" and other forms of anti-friction alloys, in some cases tough and in others hard metal being used as experience dictates. Somewhat typical examples would be given by Sn. 74 per cent., Sb. 18 per cent., and Cu. 8 per cent for "hard" metal, and Sn. 85 per cent., Sb. 7.5 per cent., and Cu. 7.5 per cent. for "soft" metal, but, of course, these do not represent all anti-friction alloys, as lead, zinc, and other metals are used as part of the content in some cases. With this kind of thing a great deal depends on the purity and cleanliness of the metals used in making the alloys, and a very great deal depends on the heat treatment afforded, this usually making it good policy to select some good brand of anti-friction metal and use that only, being careful not to use old bearings which have been re-melted, for very apparent reasons.

There are a great number of alloys not at present used in aeroplane work; either they have proved to be unreliable, or because they have not been tested in practical use, and eventually some of these last will no doubt be utilized. Iron and steel, of course, form a heavy item in the metals used, and often the strength and ductility of these are open to question, unless very great care is taken in selection. Bolts and nuts, wire, and similar material may or may not come up to standard strength when tested, and there may be some physical defects only found after close examination. The threads of bolts and nuts may not exactly fit and in screwing up an incipient fracture of the bolt may be caused, or wire may need further annealing to make it absolutely dependable, and so on through the different wrought parts, while in castings there may be holes or porosity caused by various reasons during manufacture. In cases where malleable castings of the usual annealed kind are used it is well to see that angles are sound—especially internal angles—and that the shapes of the castings are not such that holes or weak segregation groups are formed inside the castings, to which end it is wise to cut some of them to pieces with a saw to see what they really are internally. The faults arise more often from faulty design than from bad metal, attempts to form sharp angles being as much to blame as anything, as this causes a disturbance of the regular arrangement of the crystalline structure of the metal and preventing equal cooling stresses being set up. Mild steel will be found to form cavities or shrinkage holes when of a similar faulty design, and the only remedy is to alter the sectional design. In some cases wrought-iron castings are made to replace the ordinary malleable castings; but this method of securing ductile castings does not appeal to many per-

*From *The English Mechanic*.

sons, probably the trouble of securing the right kind of wrought iron and keeping it free from carbon being the cause. Wrought iron of the highest quality is a necessity where only the best test results are required, and beyond this little can be said, as the user is rarely the maker. With grey iron castings there is always room for considerable skill in selection and manipulation, and where strength combined with lightness forms the desired end there is plenty of room for skillful manipulation. A strong iron need not necessarily be hard; but usually it will chill both quickly and deeply, a chilled surface not being easily tooled as a rule, grinding having to be adopted; but a hard iron, while being "strong" as against abrasion, may be very weak both as to tensile and transverse stresses, and for these reasons of no real value under working conditions. You cannot get any casting much harder than one made from the heterogenous scrap collected by the itinerant rag and bone man, and you cannot get any very much weaker castings, such metal as this having no value in the construction of anything in which strength and lightness have to be combined, only selected new metal being dependable for good work. Soundness is, of course, necessary with all castings, and to get this only the best methods of working can be adopted, both moulding and melting having to be of the best.

In the manipulation of the metal, whether it be cast or wrought, there is no room for doubtful methods, because you cannot stop for temporary repairs when in the air.

There is ample room for experimental work; but until the war is over there will be no real opening for the results of such experiments, however good they may be, and this has to be remembered.

The Use of Creosoted Fir for Marine Construction

By Prof. Bror L. Grondal

College of Forestry, University of Washington

In the waters of Puget Sound and on the Pacific Coast generally, there are three salt water marine borers that attack and destroy untreated timber. The most important are the so-called "teredos," including the species of two closely related genera, Teredo and Xylotrya. These worm-like borers belong to the oyster family, the Mollusci, and they bore into the wood, honey-combing it with galleries. The galleries are quickly lined with calcareous or lime-like material, and the "teredos" or "ship-worms" live in the holes thus prepared just as oysters live in their shells. They do not eat the wood; the borings are eliminated through the alimentary canal without being in the least digested and assimilated by the borer. The ship-worm most commonly found in the waters of Puget Sound is not the Teredo, but Xylotrya gouldi. Teredos are, however, also occasionally found.

The microscopic free-swimming larvae of ship-worms can not develop in creosoted wood, as they are too delicately organized. Once developed, however, the presence of creosote in the wood does not deter them, as their galleries are quickly lined with impenetrable calcareous material. If small untreated spots exist on the surface of the wood where the creosote has failed to penetrate the wood because of the presence of knots, or because the wood was not evenly seasoned before treatment, the larvae can obtain foot-hold and at once extend their galleries through the wood, causing incalculable damage. In using creosoted piling or lumber for marine construction it is therefore necessary to be absolutely certain that the following requirements are observed:

1. *The piling or lumber must be well seasoned before impregnation with creosote.* If the material is not well seasoned either in the air or by artificial means such as by the "steam and vacuum" or the "boiling" processes, untreated areas are very apt to be left on the surface of the material through which marine borers and ship-worms may enter. Water-stored piling has a strong tendency to become case-hardened and excessively dry on the surface exposed to the sun, while the under side remains waterlogged. When such material is creosoted by the boiling process, the penetration of creosote on one side will be very heavy, while the other side will receive very little. This is due to the difficulty of seasoning such material to a uniform moisture content. To remedy this condition it has been proposed to first impregnate the pile with creosote before attempting to dry it, thus securing a satisfactory penetration on the side that is already sufficiently dry, and then boiling until the wet side is dry enough to take the oil, when pressure is again applied to the oil, thus securing a satisfactory penetration in this side also.

2. *The material that is creosoted must not contain large knots.* Creosote does not readily penetrate the harder wood of knots, hence large knots are very likely to offer untreated spots where ship-worms may enter. Small knots are not so serious, as such knots are more readily impregnated with creosote. A recent large purchaser of creosoted piling in Seattle (American Can Company) has attempted to overcome the bad effect of the knots by boring ⅜ inch holes about two inches deep in all knots over 1½ inches in diameter before the piles are creosoted. The holes are plugged with dry fir plugs secured with galvanized iron nails. The presence of the holes causes the knots to dry out readily so that a heavy local penetration can be secured in what would otherwise be the weakest points in the pile. The scheme has merit and will undoubtedly be much used in the future.

3. *The protective layer of creosoted wood in the piling or lumber must not be broken.* Axe chops in creosoted piling make extensive attacks of marine borers inevitable, rendering the creosoting useless. Ship-worms can also enter through the holes left by nails, dogs, bruises and other avoidable injuries which result from carelessness in the handling of creosoted material after treatment. *Creosoted material must not be framed after treatment.* Such stupidity will absolutely nullify the protective effect of the creosoting.

4. *Untreated material must not be placed in contact with creosoted material.* Uncreosoted sway braces or waling must never be used in connection with creosoted piling or timbers that are used in marine construction, for ship-worms in many cases may obtain foothold in the untreated material and penetrate the creosoted material after they are fully developed, when creosote is no longer an effective barrier. Creosote is absolutely effective in keeping out the larvae, which are most delicately organized.

5. *The total amount of creosote in piling or lumber used for marine construction is of less importance than the depth of penetration of the creosote.* Ship-worms are not mathematicians. The fact that a pile may contain an *average* of twelve pounds of creosote per cubic foot means nothing to the simple mind of the "teredo." If untreated spots exist in the surface of the pile, ship-worms will destroy the pile regardless of the total amount of creosote that has been used. The important requisite is therefore that the penetration of the creosote must be uniform. It follows, then, that the material that is to be creosoted must be free from large knots and that it must be dry when creosoted.

6. *Creosoted piling should never be over-driven.* The driving should cease when the pile no longer penetrates readily, as over-driving may produce longitudinal splits through which ship-worms will quickly enter.

7. *Creosoted lumber and piling in docks should be protected with boom sticks.* Floating driftwood under docks will abrade the surface of the piling and break the protective layer of creosoted wood. To keep the driftwood out, boom sticks should be placed just inside of the first row of piles around the dock, chained in such a manner that the sticks will not float against the piling on either side.

8. *The untreated end of the pile left by the "cut off" should be protected from decay.* Well-creosoted piles will quickly fail through decay unless this is done. The usual practice is to paint the freshly sawn end with one coat of hot coal tar creosote. This is not sufficient, but should be followed by one liberal coat of cold creosote as soon as the first coat has been absorbed. In the opinion of the writer, it would be a good practice to first give the end of the pile a good soaking with a hot 1 per cent. solution of bi-chloride of mercury in water, and after it has dried somewhat to follow this with the two coats of cold creosote.

Present specifications for piling are usually too severe in one particular, and that is the degree of straightness that is required. In driving, the piles are stressed to a much higher degree under the impact loading of the pile driver hammer than they will ever be subjected to in the completed dock where only low static loads are permitted. If the piling is not too crooked to be placed in the gins of the pile driver and will stand up under the driving, it is perfectly serviceable regardless of the crook and should be used. A crooked pile free from knots is immensely much more serviceable than a knotty pile that is straight as an arrow. The present specifications that demand perfectly straight piles accomplish no useful object and increase the cost of the material unnecessarily. This increase in cost, of course, falls upon the purchaser who buys piling under such specifications.

A third class of marine borer does a great deal of damage to untreated material in the same region. This borer is the crustacean known as "Limnoria lignorum," or the gribble, which belongs to the lobster family. The "Limnoria" or gribble attacks the surface of the untreated piling or lumber and cuts millions of small holes from ⅛ to ⅜ of an inch in depth into the wood. To avoid the attacks of this borer the same rules expounded above must be rigidly observed.

Inspection of creosoted material should never be intrusted to inexperienced persons, for if the inspection is poor the expensive creosoted material may prove to be almost worthless. One of the features in the course in wood preservation in the College of Forestry of the University of Washington is a number of inspection trips to creosoting plants, where the students are taught to recognize the attacks of marine borers, how to grade piling and lumber for creosoting and how to distinguish between proper and improper seasoning and creosoting. All of the creosoting companies on the Pacific Coast welcome proper inspection, but in the past much of the inspection of creosoted material has been poorly done because of the propensity engineers have to let the inspection to the *cheapest* bidder. This condition of affairs is rapidly changing, and the larger and more responsible inspection firms and creosoting plants are employing men who have been properly trained in forestry and its branches, with the result that the amount of poorly creosoted material that is produced is decreasing, and while some isolated failures are inevitable as in the case of the use of any of the materials of construction, creosoted fir for permanent dock construction on the Pacific Coast bids fair to continue without a rival.—*From The West Coast Lumberman.*

A Simple Plan for Unifying Time in the United States

The present zone system of reckoning time has always been cumbersome and unsatisfactory, causing mistakes and delays at the junction points. It is now proposed to complicate matters still more by setting our clocks forward one hour in spring and putting them back an hour in the fall. Time is something which should be absolutely uniform and consecutive. It would be hard to conceive a much more dangerous proceeding than to arbitrarily change the time standard, for it would almost certainly cause confusion and accidents. As a war measure it might be justifiable if it would really conserve needed supplies; but as a matter of fact little will be gained by setting the time ahead during the summer only.

Between the last Sunday in April and the last Sunday in September practically all the work of the country is done by daylight. If any saving of artificial light is to be effected it must be by utilizing all the daylight in winter. As it is now, the greater part of the business of the country does not begin until about two hours after sunrise, even during the shortest days of the year. Hence a great saving of daylight can be made by adopting an earlier time for the whole year.

Nor is it necessarily a greater hardship to get up early in winter than in summer. During the long nights one can easily secure plenty of sleep before the morning hours, but during the heated spells of summer it is often impossible to get any rest early in the night, and the cool hours of morning are the most valuable for sleep.

It would, however, undoubtedly be better for the country if business were as a rule transacted somewhat earlier in the day. It is also beyond dispute that a uniform time for the transportation systems of the country is a great desideratum. Both these things can be effected in a very simple manner. Let Congress adopt ninetieth meridian time as the standard time for the whole country, except Alaska. Then let the legal hour of noon be fixed for each zone in such a way that legal noon shall in general be slightly before solar noon.

Thus east of seventy-fifth meridian the time of legal noon would be ten o'clock. Between the seventy-fifth and the ninetieth meridians legal noon would be eleven o'clock; between the ninetieth and one hundred and fifth meridians, twelve o'clock, and west of the one hundred and fifth meridian, one o'clock.

Banks and government offices would open accordingly, and other business would naturally follow, making the hours of work before the legal noon hour approximately equal to those after that period. Some confusion would inevitably result at first. People in some of the zones would have to change their time of rising, eating meals and retiring; but I believe in a very few days every one would become accustomed to the change, and the country would have the inestimable advantage of a uniform time throughout its whole territory.

Factories might find it advisable to open an hour later during the winter months. It would certainly be easy to do this without interfering with the scheme as outlined. In any event, individual convenience and preference must give way to the general good of the country. I feel confident that the system here proposed would prove a boon to the railroads and would facilitate business.—*Jermain G. Porter in Popular Astronomy.*

How Things Break—II

A Study of the Mechanism of Fractures in Materials

By Charles Freminville

[Concluded from Scientific American Supplement No. 2233, Page 249, October 19, 1918]

The distances between surfaces overlapping each other, in such succession as to divide the body into thin blades, are often exceedingly small (less than one-tenth of a millimeter) and this must be carried in mind when we are trying to realize what is the nature of the cause which may have produced such result, and of which we shall say a few words further on.

The existence of these surfaces which we shall call "elementary surfaces" (in opposition with the main surfaces dividing a body in several pieces), and the manner in which they are shooting forth and extending, is certainly very puzzling, but before trying to make deductions we should like to see the starting point of one of these surfaces. Here we meet with a great difficulty. We see the elementary surfaces developing not only from the neighborhood of the focus, but also from points rather distant from that focus and, practically, from everywhere, but we always find them coming from behind the main surface. They are more or less arranged like the slates or the shingles of a roof. The starting point is hidden in the mass.

By choosing convenient samples we can clearly see that one elementary surface has developed out of a cluster of small surfaces contained in a rather sharp cone as shown in Fig. 10a, which is very typical. Out of this cluster of surfaces, one or two have developed to play the rôle above described. We find also that the dull surfaces are produced by a great number of such clusters emerging from behind. Again, if we return to the splintering focus, we find that the origin of its development is a cone of the same kind, (Figs. 10, 10a, 10b, 10c) the axis of which is perpendicular to the bright surface, and consequently parallel to the surface of the slab, and situated at a short distance inside that surface. One or two surfaces of the cluster, developing more than the others, and turning at right angle, have formed the central surface of the Splintering Focus.

Our study of the fracture surfaces has made us come to the conclusion that, in brittle material, every fracture surface, from the starting point of the splintering focus down to every small indentation met on the surfaces originates in the same manner, from the inside. This is not special to brittle material, and is observed also in material which can be bent permanently or stretched to a very great extent, such as a sheet of gelatine. A sheet of gelatine can be divided in two pieces by *tearing*, a process which seems to be entirely different from the sudden fracture resulting from a blow struck on a slab of glass. One would think that the pull given on each of the two sides of the rent concentrates at the parting point a stress propagating the rent. This is not what happens. All over the surfaces of the rent, of the piece of gelatine torn in two, we meet small elementary surfaces coming

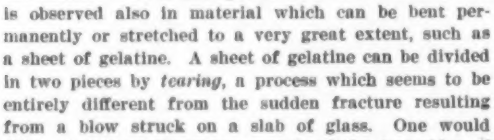


Fig. 10b. Same arrangement as above observed in pieces of steel tyres broken at impact test.

from behind and overlapping each other (Fig. 11), very similar to those we have observed in brittle material. The production of these surfaces causes the characteristic noise heard during the tearing process, and it is worth noting that wrinkles are produced, for which the action of the pull given is not accountable. It is clear that elementary surfaces have sprung from both sides of the point where the partition due to the stress may have been expected. These small surfaces cutting the material through have, so to say, overridden the action of the stress.

The same process is the one we meet in every fracture including the fractures of steel, (Figs. 12 and 13), and we can safely say that the elementary surfaces forming the fibrous or silky appearance of certain fractures are due to the same fact. The inspection of a steel shaving (Fig. 14) discloses another remarkable example of the same fact under a different form. The surface cut by the tool is very often perfectly continuous and smooth, whereas the outer portion of the shaving has been dislocated by numerous splintering surfaces, starting a little above the cutting edge of the tool (Fig. 14a). It is clear that the greatest stress put on the tool has for effect to produce that splintering dislocation and so to make the cutting

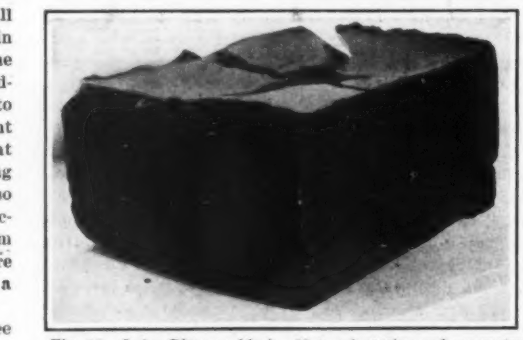


Fig. 10. Judea Bitumen block. Note orientation and symmetry in the surface fracture.

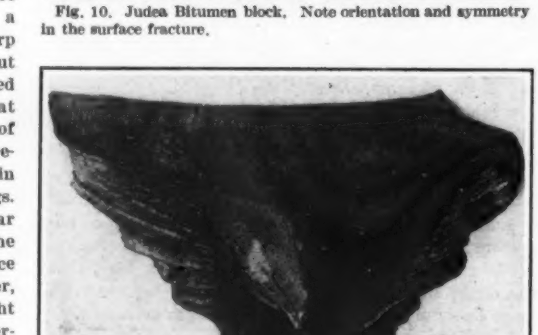


Fig. 10a

of the tool easier. It is therefore of great importance that this splintering should be rendered as easy as possible. Splintering being synonymous of brittleness, and cold rendering all bodies brittle, it is only natural to cool the metal with a flood of water in the neighborhood of the point where the chip is formed, according to the most improved practice, should have such a great importance to facilitate the cutting of the tool. When oil is used it prevents the temperature from rising by

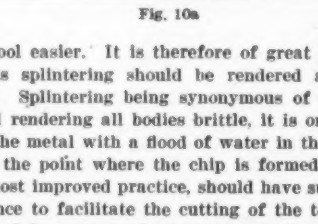


Fig. 10c

allowing the surfaces of the splinters already formed to slip one over the other with a small production of heat, which comes to the same thing.

But it may be said that in the fractures we also meet with extensive smooth surfaces, in which the numerous clusters, which we have considered as a consequence of straining, are not apparent, and it may be asked if these surfaces are not due to the direct action of stress. It is easy to see that this could not be the case, for those surfaces are very often cutting the body concerned in such thin blades that it is not possible to conceive how an important stress could be applied on them transversally.

To find an explanation for the production of these smooth surfaces we have to go back to the causes usually producing smooth surfaces. We know only two such causes: the cutting of a sharp tool or the action of an abrasive, such as is used to polish glass. It seems evident that nothing in the process of development of a fracture can be compared to the cutting tool. Queer as it may appear, we find that an action of the abrasive kind is not only possible, but even likely to come into action, for we may conceive that the thin layer of the smooth fracture surface already formed may be a favorable field for very rapid surface motion, and that these motions may bring into contact particles in such conditions as to cut the said smooth surface.

These facts are experimental arguments which seem to be decisive when we have to choose between the various existing theories about the causes producing ruptures. These theories can be summed up as follows: "what in the production of rupture is the most important factor to be considered: *Stress or Strain?* From what we have seen, we cannot hesitate in saying that the most important factor is *strain*, for we have not met a single case in which stress is not overridden by strain, this last factor deciding the rupture before stress could come into action. This, however, is in accordance with the most recent theoretical researches.

It is rather disappointing to find that the stress applied to the material is not the direct cause of the fracture, because stress is so much easier to realize and to measure than strain. Nevertheless, if we want to face the truth, we must bear in mind that every fracture is originated, and also propagated, by a straining action producing the splintering processus above described, and that it holds good even for soft material.

As an object lesson of the influence of Strain in rupture we may give some attention to a proposition which is the reverse of the main object of our study: "How things do not break."

We know that glass is exceedingly brittle when it has just been worked into different shapes. It becomes far less brittle after being properly annealed, and when submitted to a proper heat treatment it acquires such properties that it can be termed *unbreakable*. A sheet of unbreakable glass can be bent, without breaking, to a much greater extent than a sheet of perfectly annealed glass. However, the heat treatment does not seem to have brought about a change in the texture or the molecular cohesion of the matter; but it has worked out a very great change in the condition under which the straining action comes into play, namely, in the pressure perpendicular to the direction in which the molecules are solicited to slip on each other under the straining action. Unbreakable or chilled glass has been produced in the following manner: the manufactured object being heated to give it a putty consistence, is then chilled in a bath. The result is the forming of a solid crust while the inside being soft adapts itself to the shape of that crust. During the subsequent cooling of the piece, the inside, being at a higher temperature than the outside, is bound to become more contracted, causing the inside fibres to be under ten-

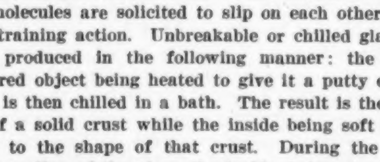


Fig. 11. Scheme of tearing, with cracks that accompany it.

sion and the outside fibres under compression. It may be understood that this compression creates a tendency of the neighboring fibres to part from one another, *i. e.*, a negative pressure. The same reasoning will show that the outside fibres of a piece which has not been annealed undergo an important transverse pressure, and we are led to conclude that the chief factor which makes the straining effort dangerous is the transverse pressure. This can be born in mind and made use of, for it is possible in a great number of cases to put machinery pieces under such conditions that this transverse pressure is properly directed, as shown in the accompanying sketches.

The Annealing of Glass

Glass has to be annealed to remove any strains set up in it by improper mechanical or thermal treatment, and the presence and development of strains is revealed by passing a beam of polarized light through the glass. Although this optical method of examination has long been applied by physicists and manufacturers of optical glass, it is hardly known to the average glass manufacturer. The Department of Glass Technology of the University of Sheffield has therefore investigated the annealing of glass and the relationship between the composition of a glass and the suitable conditions for its annealing with the special object of facilitating the optical examination and of devising simpler mechanical methods of testing. "Notes on the Annealing of Glass," giving an account of these investigations, were communicated to a recent meeting of the Society of Glass Technology, by Messrs. Solomon English, M.Sc., and W. E. S. Turner, D.Sc.; the latter is in charge of the Department of Glass Technology at Sheffield. Though these notes were only offered as introductory, the details given are of considerable interest.

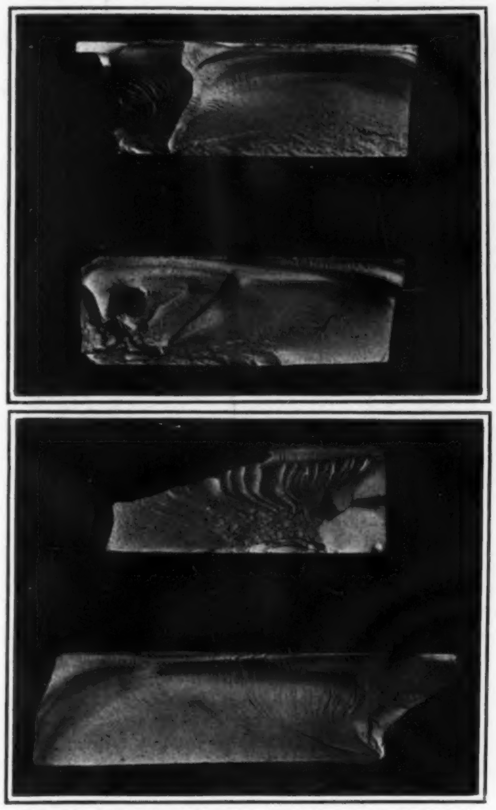
In a polarization apparatus the beam of light, polarized by passing through the first Nicol prism, is stopped by the second Nicol, when the two are crossed. On introducing a cylinder of glass, strained with fair regularity, between the two Nicols, some light will pass and a system of colored rings will be seen, the number of rings increasing with the intensity of the strain. The strain can be removed again by proper annealing of the glass, and the glass manufacturer is mainly interested in three things: The "upper" annealing temperature at which the strain can rapidly be removed without risk of deforming the glass; the "lower" temperature at which the strain can be removed at a slow rate; and the quickest rate of cooling which may safely be used for cooling between the upper and lower temperatures without setting up new strains. For their optical examination, English and Turner use cylinders, 3 cm. in length, with plane polished ends, which are placed in a tubular electric furnace. Such a specimen will, if severely strained, *e.g.*, show seven rings and the central black cross. As the temperature rises, the rings broaden and seem to chase one another out of the field of view; the number of rings thus diminishes, they become indistinct and vanish, leaving only the black cross, which finally occupies the whole field; that is to say, the field is uniformly dark when all the strain has been removed. In the experiments the times were determined at different temperatures which were wanted both (*a*) for clearing the field of rings and (*b*) for making the field quite dark, and it was observed that a temperature difference of a few degrees in a lehr or other annealing oven made a large difference in the time required. Thus the results were:

Temperature.	Time Required. (*a*)	(*b*)
500 deg.	20.5 hrs.	?
550 "	50 min.	Not black after 9.5 hours.
600 "	20 "	4.5 hours.
625 "	—	18 minutes.
630 "	—	10 "

The glass of these experiments was of a fairly high "upper" temperature. In a lead glass, the upper temperature of which was only 450 deg. C., the (*a*) were 35 minutes, 20 minutes, —, and the (*b*) more than 6.5 hours, 130 minutes, 2 minutes at the temperatures of 400 deg., 425 deg., 450 deg. C.

Rapid annealing requires softening of the glass, and it was therefore investigated whether the rate of bending of heated sample rods and the rate of annealing would run parallel with one another. For this purpose a rod of the glass mounted axially in a horizontal tubular furnace, was fixed at the one projecting end, while the other free end played over a vertical scale; the sagging of the free end was measured. The general shapes of these curves proved the assumption just stated, and that glass anneals rapidly when the softening begins. Messrs. Beatson, Clarke and Co., of Rotherham, continued these tests. A test rod, 1 yard long, ¼ inch in diameter, was drawn out from the metal in question, and supported at its centre on a brick, which was placed on the pan carrying bottles down the lehr. Arriving at the cool end, the ends of the rod were each found to have sunk by ½ in.; in that case the bottles were found to be strained on examination. When the glass remained in the hot zone for about 15 minutes and was satisfactory, the ends of the rod had sunk by about 3 in.; with prolonged heating at higher temperature the bending became excessive.

As regards the rate of cooling, English and Turner find that the cooling rate should neither be uniform throughout the period, nor first be accelerated and then slowed down again, or *vice versâ*, but that the glass may, first, *i.e.*, just below the annealing temperature, be cooled rapidly; as the glass stiffens the rate of cooling should be very slow, until the glass has become rigid, when the rate may again be accelerated. Thus the rate of cooling should be variable. Three stages would probably prove sufficient. In the first stage, glass of an upper annealing temperature of 585 deg. or 590 deg. C. may be cooled at the rate of 25 deg. per hour down to 500 deg. C.; during the next stage 500 deg. to 400 deg. C., even a slow rate of 9 deg. per hour gave rise to some strains; in the cooling-off stage the rate could once more be raised. Each stage would correspond to a different section of the lehr, and the question is, whether the annealing oven can economically be so constructed as to admit of varying the rates of cooling. When only one variety of glass is made, the mechanical difficulties would not be great; but when glassware of different compositions and different thicknesses are to be annealed together, which is the common practice, the fastest rate of passage will have to be adopted, it is pointed out, even if this rate be that of the slowest glass to be annealed. How much the chemical composition influences these rates is shown by the data of the paper. A glass containing 30 per cent. of lead oxide had to be annealed at 450 deg. C.; it could be cooled down to 400 deg. at the rate of 120 deg. per hour, but between 400 deg. and 300 deg. the rate should not exceed 50 deg. per hour, while below 300 deg. the high rate of 300 deg. per hour was permissible. These figures concern a rod 7 mm. in thickness. For electric lamp globes this glass could be cooled at the rate of 12 deg. per hour down to 300 deg. C., and then be allowed to cool off in the open air. Wine glasses could be treated in similar ways. Lime-alkali glasses had to be cooled slowly, at 10 deg. per hour, from 550 deg. down to 320 deg., the further cooling being completed in 3 hours. Boric acid glasses (with 23 per cent. of B_2O_3) proved surprisingly difficult to anneal at 570 deg.; as borax acts as flux and diminishes the expansion coefficient of a glass, one might expect ready annealing; but the important factor is the rate at which the viscosity varies throughout the temperate range in which annealing can occur. Chemical glassware containing, *e. g.*, 64 per cent of silica, 10 per cent. of alumina, 7 per cent each of barium and calcium oxides, and 11.5 per cent of soda and potash, proved the most troublesome; between 500 deg. and 400 deg. this glass has to be cooled so slowly that Messrs. English and Turner had so far failed to get an 8-mm. rod through this region without some signs of strain.—*Engineering.*



Figs. 12. Splintering in hard tool steel is quite similar to splintering in glass or bitumen.

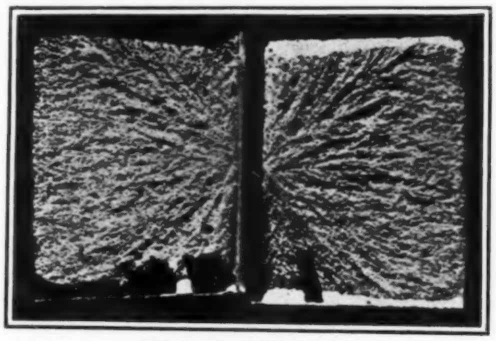


Fig. 13. Break in hard steel.

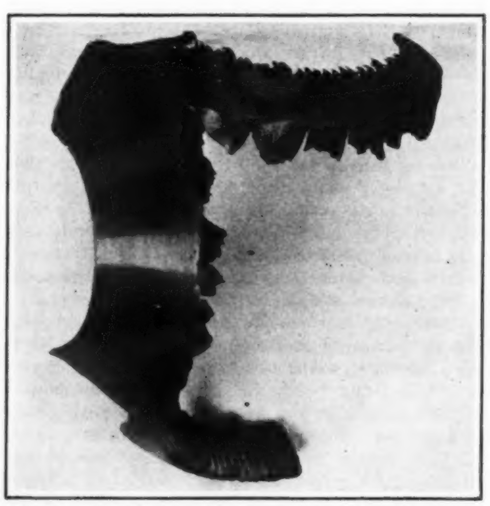


Fig. 14. Steel shaving 0.75 diam. Note the continuous surfaces cut by the tool and the dislocation carried out above that surface by the splintering processes.

Fig. 14a

Germans Learned Poison Gas Warfare from Savages

As is well known, the Germans were anticipated by some savage tribes in the use of poisonous gas for war purposes. In a paper entitled "Palisades and Noxious Gases among the South American Indians," by Mr Erland Nordenskiöld, in *Ur Ymer, Tidskrift ugiven av Svenska sällskapat för Anthropologi och Geographi* (Arg. 1918, H. 3), he quotes authorities, such as Staden, Oviedo y Valdés, and Thevet, to show that tribes like the Tupinambá and Guaranis of the Brazil littoral and on the Rio Parana used poisonous gases in attacking fortified villages. Men went in front of the attacking party, each holding a pan with embers in one hand, and ground red pepper in the other; when the wind was against the Spaniards they sprinkled the pepper on the embers. This was also done in attacks on the Spaniards in Venezuela. In the same way pepper was largely used in exorcising demons and evil spirits. The use of this pepper, known as Aji, would soon be discovered by these Indians, who cultivated the plant extensively. It was only necessary for someone to upset a basin of Aji into the fire, and a hut would soon be cleared of its occupants. The use of the smoke in warfare would be a natural development.—*Nature.*

New Method of Treating Positive Electrodes of Primary Batteries

A new method of treating the positive electrodes of primary batteries, with a view to introducing metallic oxides as depolarizers, has been invented in France. The electrode consists of a shallow plate of copper or iron presenting numerous conical points to the alkaline element in the cell. The edges of the plate are bent so that it becomes a form of shallow box into which the depolarizing oxide is introduced. This material is mixed in a powdered state with a suitable alkaline hydrate or alakline earth, and introduced into the interior of the box formed by the positive and a zinc plate as negative. The whole is sealed with rubber, a small vent being inserted to allow for the escape of gases, and cased in metal stiffening bands.—*The Engineer.*

The Evolution and Destruction of Life*

Effect of Modern Agencies on Wild Birds and Animals

By William Beebe[1]

I.—FUTURE EVOLUTION

About six thousand three hundred and seventeen years ago a very excellent bird artist painted a truthful frieze of wild geese upon a tomb in Egypt. There are three species, and with such care were the birds delineated that every marking is distinct to-day, and we realize that the geese which are now spending the winter on the Nile are the self-same species as those which were trapped by the Egyptians of the earliest dynasties. To us this period seems long; but let us multiply it a score of times, back to the life-time of the birds whose fossil bones we now find in caves, and we realize that even one hundred thousand years ago, many birds differed little or not at all from their living descendants of to-day.

Farther back than this we need not go, although even eight or nine millions of years will but take us to bird-like creatures which were volplaning through the air on feathers as perfect as any we know. The main thought is that all the emphasis of evolution of the animal world is nesessarily laid on past time. Upheavals and cataclysms there have been; whole faunas wiped out by ice, by volcanic fire, perhaps by parasites. But always there was a new starting point; a continent from which the barren places could be repopulated. Always there was final cessation of the devastation; ultimate freedom for healthful competition; room for new races to be run.

The present, philosophically speaking, has no meaning for us. It is better to consider it as a temporal vanishing point, an impalpable eddy in the stream of life, itself composed of the inwhirling current of the future, passing out unceasingly into the slack water of past time.

In the distant past, then, all the organic evolution of which we are cognizant has taken place. The more immediate past—the historical—is barren. The present is so fleeting we can ignore it. The future is hopeless. Man has come and man has conquered, and already we see foreshadowed the beginning of the end in the hemming in of wild life in preserves, and in the ceaseless legal warfare over the actual existence of many wild creatures.

Until two scant centuries ago the scattering of red men over North America could hardly have interfered with any mutation or other variational change of the fauna. To-day, only a fraction of the wild life survives, with absolutely no chance ever again to give rise to any new types, unless in forms like the house sparrow, degenerately parasitic on civilization. Throughout the Far East the Mongolian hordes are already brimming over, settling on neighboring land and islands and clearing off the jungle. The wild life of whole districts is being wiped out that we may have tires for our automobiles. Our head-lines flare when one of our own kind is run down in the crowded streets of our cities; no one gives a thought to the small folk of the jungle whose whole race has been blotted out by the inception of these resilient rubber rims of juggernaut.

The historian finds the future of absorbing interest; the morrow holding inexplicable surprises. In the evolution of the Mexican people, *mañana* may yield a renaissance or a cataclysm. But in spite of all the wonderful adaptations of the classic Mexican axolotl—that versatile salamander christened by the Aztecs—its race is run. It can live the life of a fish, swimming and breathing with gills; or it can become a land creature with ambulatory limbs and lungs and produce its offspring under either condition. But its only concern at present is with life itself. Its hope now is not for progress, but for a few more years of mere existence.

We cannot consider our domestic animals. We may breed cows which will produce astounding quantities of milk; hens may lay two eggs a day; unheard-of monstrosities in the way of fancy pigeons may come into existence. But this is not evolution. These are merely unstable toys of man; living but artificial; parasitic puppets which have no existence apart from yard or cote. Even the semi-feral rat who gnaws his way into our cold storage warehouse and there in course of time grows a longer coat of fur, can hope for nothing. In a hundred generations his brood would perhaps begin life less naked than to-day. But in five generations the cold-storage warehouse will have become so important a feature in the hoarding of food for hungry masses of humanity that it will be rendered rat-proof. Even a long-haired race of rats is a futile hope!

The only reason why the splendid wild creatures of the earth have held their own as well as they have, is because man in his travels has hitherto been confined to practically two planes of space. We see what incomparable success has been given to the world of insects and of birds by flight. Rising physically, the one above their worm-like ancestors, the other soaring over their reptilian forebears, without strength or weapons they have outstripped all other creatures and to-day divide the earth with mankind; at once his best friends and his most dangerous enemies. Our imagination readily pictures the future when the very few years have passed which separate us from complete success in this aerial field (today our very language is still of the earth, earthy!) Then, the most isolated of nesting haunts and the uttermost routes of migration will be bared to the commoner—the aerial pot-hunter. The farthest recesses of New Guinea mountains and of Brazilian jungle will be tragically accessible to man. And with the entering of mankind into the third plane of space, earth will wholly cease from her age-old, epoch-slow unrolling of the glories and mysteries of terrestrial organic evolution.

Earth will cease, I said,—I should have said dry land, for just beyond low tidal mark, nature will still defy mankind. And in these icy, silent, lightless ocean depths, life will still be undisturbed. Thousands of air-ships will come slowly sinking through the blue water overhead, but only to form a resting place, for a brief season, for barnacles and worms; then to dissolve to ooze.

This is a brief of the more distant future. For the present we should redouble our efforts to preserve at least the nobler animals and birds for a few generations.

II.—DESTRUCTION

A period of seventeen months spent in Asia and the East Indies studying the life-histories of wild pheasants, left me with a decidedly pessimistic outlook as regards even the more immediate future of these splendid birds. I realized that even if I repeated the trip at once there were some which I should not be able to see again. The agencies working against the various pheasants were multiple and cumulative, and all had to do, directly or indirectly, with the changes wrought by the invading Caucasian, or at least the influence of his habits, weapons and diet.

In India and Burma, where for untold generations the law of the ancient religions has been kind to the life of wild creatures, there is, in the more out of the way places, a slackening of this gentle religious feeling. With the increase of sportsmen, and the disregard of Sahibs in general for the wild creatures, there has been diffused a conscious, or unconscious laxity, hardly noticeable to the casual onlooker, but discernible when away from the more densely populated centers. In some isolated districts this takes the form of wholesale trapping, the indirectness of this mode of taking life serving to gloss over the ultimate result. Thus also do the fishermen of some of the southern coasts keep faith in themselves and their belief. They cast their nets and enmesh whole schools of fish, but then hasten with them to the beach, and gently and considerately lay their catch upon soft grass and moss. Later, when the fishermen return, they express a naive surprise to find that the fish have expired, when of course they are available for food with not the slightest infringement of the law. If this disregard for tradition should ever become more widespread it would work havoc with the trusting peafowl and junglefowl which scream and crow near the villages, and the kaleege which fatten on the crops of rice and barley.

In the Malay States and elsewhere another factor becomes apparent. One may ride for mile after mile and, instead of primeval jungle, see nothing but hundreds of thousands of spindling rubber trees, sprouting from raw, fresh earth with no hint of the marvelous fauna and flora, the orchids, the birds, the four-footed creatures of the deep jungle, which peopled this land shortly before. This is as it should be; man is stronger and is inheriting the earth, but it is sad to see the age-old course of things so suddenly, so blatantly interrupted. The call of the fireback and the wonderful cry of the argus never resound among these saplings, planted with mathematical accuracy and cherished with the care which a lucrative future demands.

Wherever the Englishman holds sway, there the pheasant gets fair play and a chance for the life of the species. But the plumage hunter runs riot in Nepal and Yunnan. I have seen valley after valley despoiled of their one or two pairs of magnificent resident tragopans; and only to beguile the days of the lowly Nepalese shepherd, without caste, but with all the time in the world to make snares. In Burma the terrestrial birds and animals of the valley are sometimes completely wiped out by a half-mile bamboo fence, punctuated every few yards with dead-falls.

Even in China, where for unnumbered years the pheasants have taken their moderate toll of rice and repaid with the compound interest of an insect diet the rest of the year,—even there changes are at hand. With the more or less successful adoption of foreign hats and garments, seems to have occurred a yearning of the inner man for change, from rice and fish to pheasant flesh. And in many parts of the Celestial Republic the birds are paying heavy toll to this demand. Not only this, but tens of thousands of pheasants were being sent up and down the rivers to huge cold storage warehouses, to be frozen and sent to European restaurants.

A new, wholly unexpected change has now come to pass, and the terrible history being made in Europe will mean a new, however brief, lease of life to the creatures of the Eastern jungles. The capital necessary for many of the rubber plantations will not be available. The demand for this product and for the luxury of frozen pheasants will lessen. The milliner will be unable to sell his ill-gotten wares, and the pressure of Caucasian commercial influence will lighten everywhere. Hundreds of intended clearings will be abandoned, projected buildings will be deserted and the voice of the wild pheasant—the firebacks, the monal, the koklass, the argus, the golden and the silver, will, for a time, increase the volume throughout the jungles of the Far East. It may, however, be the last pause in the slow, certain kismet which can only result finally in the complete extinction in the wild state of these splendid but intolerant birds.

*Bulletin of the New York Zoological Society.

[1]Curator of Birds, N. Y. Zoological Park.

Paving Bricks from Blast-Furnace Slag

The characteristics of the bricks depend more on the manner in which the slag is cooled than on its composition. The following process is recommended: The slag from the furnace is poured into a tilting frit-furnace and any additional material (such as 10—20% of silica or iron oxide) required to bring it to a desired composition are then added. The mixture is brought to a quiet fusion, and run into moulds. The moulds with their contents are immediately placed in an annealing furnace at the softening temperature of the bricks, and are maintained at this temperature until the bricks are uniform throughout; or the bricks are buried in sand. The rate and mode of annealing are of great importance and determine whether tough, good bricks or brittle ones are produced.—*J. B. Shaw in Trans. Am. Ceram. Soc.*

Quenching Large Forgings

The subject of quenching oils for forgings was discussed recently at a conference of the American Drop Forge Association. In a paper by Mr. G. W. Pressell, the author said that the water quenching of large forgings is very sharp and severe, and if not properly handled often results in the failure of the piece after working. The quenching of forgings in oil is fool-proof, and the expenditure of money required properly to equip the hardening department with tanks and cooling systems was declared to be fully warranted. The author said the ideal quenching medium for forgings would be a water soluble material which, when mixed with water, would give a quenching speed through the critical range equivalent to that of water, and from the critical range to the atmospheric temperature equivalent to that of oil. However, a mixture of oil and water has proved unsuccessful. Spreading a small quantity of oil on the surface of water used for quenching to reduce the sharp effect of water has also been tried, but without success.

Scent-Producing Organs of Insects

A REVIEW of the literature shows that the substance produced by any scent-producing organ is secreted by unicellular glands which so far as known are modified hypodermal cells. On this point Gazagnaire (1886) remarks that glandular cells of hypodermal origin are widely distributed in insects. They secrete the various fluids exuding through the chitin, and since their histology is so similar it might be admitted that they have the same general structure. For description, scent-producing organs may be divided into five types based on their devices for disseminating the odor and for storing the secretion as follows: (1) No special device for disseminating the odor or storing the secretion; (2) gland cells associated with hairs and scales as a means of scattering the odor more effectively; (3) "evaginable" sacs lined with hairs connected with gland cells as a device for storing the secretion and distributing the odor; (4) articular membranes serving as pouches for storing and preventing a too rapid evaporation of the secretion; (5) specialized tubes and sacs acting as reservoirs for storing and discharging the secretion.

The first type is the simplest of all five types. It is best represented as unicellular glands uniformly distributed over the entire body surface as found in several beetles. In this type of scent-producing organ the secretion passes through the chitinous tubes to the exterior where it spreads over the surface of the chitin surrounding the exits of the tubes.

In regard to spreading the secretion over a wider area, the second type is much more highly developed than is the first type. This is accomplished in most cases by the secretion spreading over the surfaces of many large hairs arranged in tufts which may be expanded into a fan-shaped figure. In the second type the secretion from the gland cells passes into the hairs and scales and then spreads over their surfaces, whereby the odor from the secretion is more effectively disseminated.

In regard to storing the secretion in an "evaginable" sac, the third type is a little further advanced than the second type. The sacs are evaginated by blood pressure and retracted by muscles, and the odorous substance may be more or less retained in the invaginated sacs, but when the sacs are evaginated, like the fingers of a glove, all the odor escapes.

In regard to storing the secretion, the fourth type is more highly organized than any one of the preceding types. The scent-producing organ of the honey-bee belongs to this type, and it is one of the most highly developed organs of its kind. At this place might be mentioned some unicellular glands found in ants. In the petiole of the worker ant of *Myrmica rubra*, Janet (1898) found an invaginated chamber; at the bottom of the chamber may be seen the exits of the tubes which lead to a bunch of unicellular glands. He also found in the same ant two small groups of unicellular glands beneath the articular membrane between the ninth and tenth abdominal terga. These glands are also connected with tubes which run to the exterior. Both of these organs may possibly be scent-producing organs, and may be similar in function to that of the honey-bee.

Relative to storing and discharging the secretion as a means of defense, the fifth type is the most highly organized of all the five types of scent-producing organs. It is thus seen that there is a wide variation in organization between the lowest type and the highest type. All of those organs belonging to the first four types are used in all probability for alluring purposes and as a means of recognition, while those of the fifth type are perhaps used mostly as a means of defense. Of the scent-producing organs used only for recognition, that of the honey-bee is probably the most highly organized.

ORTHOPTERA

In the ear-wig, *Forficula auricularis*, the scent-producing organ consists of two pairs of lateral, saclike invaginations located in the third and fourth abdominal terga. The walls of these sacs, the reservoirs, are composed of unicellular glands.

In both sexes of the roach *Corydia* two pairs of caruncles or evaginated saclike appendages serve as the scent-producing organ. These appendages are located on the pleura of the first and second abdominal segments. Unicellular glands lie in their walls. In the roach *Periplaneta* there appear to be at least three scent-producing organs. The males have anal glands and probably the females (the writers did not determine the sex) have a pair of lateral pouches in the articular membrane between the fifth and sixth abdominal terga. These pouches are lined with hollow hairs into which the secretion from the unicellular glands empties. The same individuals also have a pair of tubular glands lying near the pouches. The same species has a fourth glandular structure lying in the sixth abdominal segment and opening between the sixth and seventh sterna. In the male roach *Phyllodromia germanica* the scent-producing organ consists of two double pouches, one of which lies in the articular membrane between the fifth and sixth, and the other between the sixth and seventh abdominal terga. The unicellular glands lie beneath the chitinous lining of these pouches.

In both sexes of the walking-sticks the secretion from the scent-producing organs is discharged through a pair of pores on the pro-thorax. The glands are paired, are ribbonlike blind sacs with stout walls, and lie in the mesothorax and prothorax. The gland cells certainly lie in the walls of these sacs, although information in regard to this point is wanting.

In two genera, *Eugaster* and *Ephippiger*, belonging to the Locustidæ, reflex bleeding occurs. The liquid issues from a pair of vesicles on the thorax near the bases of the front pair of wings. More information concerning the source of this liquid is lacking.

In the male cricket *Hadenoecus subterraneus* the scent-producing organ is a pair of appendages protruded from slits between the ninth and tenth abdominal terga.

HEMIPTERA

Scale insects emit an odor, but the anatomy of the scent-producing organs has never been studied and the external openings of the glands have never been located.

In the adult heteropterous Hemiptera, the scent-producing organ is a pair of tubular glands located in the posterior part of the metathorax or in the anterior part of the abdomen. The secretion from the glands is emitted through a pair of pores between the bases of the second and third pairs of legs. In *Pyrrhocoris apterus* a quite complicated organ is found; here there is a saclike cavity in the metathoracic sternum. A reservoir connects with the sac and a dichotomously branched, collecting tube runs from the kidney-shaped mass of unicellular glands to the reservoir.

TRICHOPTERA

The scent-producing organs of the male caddice fly, *Sericostoma personatum*, are the wide maxillary palpi. These appendages give off an odor, but the anatomy of them has not been studied.

COLEOPTERA

The simplest type of a scent-producing organ in beetles is composed of unicellular glands distributed over the entire body surface. In some beetles these unicellular glands are grouped and thus form glands varying considerably in complexity. In *Malachius* two pairs of caruncles serve as the scent-producing organs; unicellular glands lie in the walls of these structures. In *Dytiscus*, *Gyrinus*, and *Acilius* two different kinds of liquids issue from unicellular glands located in the articular membranes between the thoracic segments. The liquid emitted at the femoro-tibial articulation during the reflex bleeding of certain beetles seems to be secreted by two types of unicellular glands at this location.

The highest type of a scent-producing organ in all insects is the anal glands of beetles. These glands have been found in the following families and subfamilies: *Cicindelidae, Carabinae, Harpalinae, Feroniinae, Brachininae, Dytiscidae, Gyrinidae, Staphylinidae, Silphidae*, and *Paussidae*. They are usually paired, vary considerably in complexity and are probably present in both sexes. The most complex form consists of an efferent canal, a spherical capsule, a reservoir, collecting tubes and unicellular glands, each of which contains a radial vesicle from which runs a secreting tubule to the collecting tube.

LEPIDOPTERA

Butterflies.—The scent scales on the wings constitute the almost universal type of scent-producing organs in male butterflies. A unicellular gland lies at the base of each scent scale. A pair of invaginated sacs located at the ventro-posterior end of the abdomen, has been found, however, in the males of *Danais septentrionales* and *Euploca asela*. These sacs are partially lined with scent hairs and at the base of each hair lies a unicellular gland. In the female of *Euploca asela*, the same organ is present, but in addition there is a circle of scalelike, scent hairs around the anus. In the female of *Gonopteryx rhamni*, the scent-producing organ is a single invaginated sac similarly located. In the females of the maracujá butterflies, a pair of styled knobs located at the posterior end of the abdomen serves as a scent-producing organ.

Moths.—The most common type of scent-producing organ in male moths is a tuft of scent hairs on the tibiæ of the third pair of legs. Occasionally, however, tufts of hairs are found on the tibiæ of the first and second pairs of legs. A unicellular gland lies at the base of each scent hair. Another quite common type in male moths is composed of a pair of scalelike, scent hairs located at the base of the abdomen. Each tuft lies in a groove on either side of the body in the pleura belonging to the first and second abdominal segments. A large unicellular gland lies at the base of each scent hair. In the males of *Leucarctia* and *Pyrrharctia*, a pair of invaginated sacs located at the ventro-posterior end of the abdomen serves as a scent-producing organ; these sacs are lined with hairs.

In the female moths *Taumatopoea* and *Stilnotia* the scent-producing organ consists of a paired tuft of scent hair near the anus. This organ in the female of *Orgyia* is a scent groove in the articular membrane between the eighth and ninth segments just above the anus. Unicellular glands lie just beneath this thin membrane. The scent-producing organ in the female of *Bombyx mori* is the most highly developed of any found in the female Lepidoptera. This organ is a pair of invaginated and greatly folded sacs located at the posterior end of the abdomen; beneath the chitinous lining of these sacs lie the unicellular glands.

HYMENOPTERA

Ants emit characteristic odors, but as yet little is known about their scent-producing organs, nevertheless, a well-developed organ has been found in the petiole, besides unicellular glands beneath the articular membrane between the ninth and tenth abdominal terga, and also some around the femoro-tibial and tibiotarsal articulations. A quite complicated, paired anal gland has been found in a few species belonging to one subfamily of ants. Many wild bees and wasps emit strong odors, but their scent-producing organs seemingly have never been described. This organ in the honey-bee consists of a pouch which is formed by the articular membrane between the fifth and sixth abdominal terga. Unicellular glands lying just beneath the membrane secrete a volatile substance which admirably serves as a source for odors.

* An abstract from Smithsonian Miscellaneous Collections, Vol. 68, No. 2, "Recognition Among Insects," by N. E. McIndoo, Ph.D.

Light Scattered by Dust-Free Air

SINCE Tyndall made his famous experiments in 1872, it has been assumed that the light scattered by dust-free air is too faint to be observed with the small thicknesses which can be used in the laboratory; although it has been well established that air molecules are competent to produce such scattering. Prof. Strutt has, however, recently succeeded in demonstrating the effect experimentally. He states that the chief essentials for success are to avoid, as far as possible, stray light diffused from the walls of the vessel used and to observe the beam transversely against the blackest possible background. He employed a cross-shaped vessel made of brass tubing of 1½ in. diameter, painted dead black inside. A beam from an arc was directed down one cylinder, being admitted through a quartz window, while one-half of the other cylinder formed a black cave against which the beam was viewed through a glass plate covering the end of the other half. The air was dried and then filtered through a tube 4 ft. long filled with cotton wool. It was forced into the vessel under pressure, so that while dust-free air might leak out, ordinary air could not leak in. Viewed as described there was a blue track along the beam which, though much fainter than the track seen with ordinary air, was visible without difficulty when the eyes had been rested in the dark. Several tests were applied to show that the effect observed was not due to residual dust. No change was produced by further filtering, and Aitkens' method for counting dust particles failed to reveal presence of a single one. The blue track was examined spectroscopically to eliminate the possibility of the effect being due to a fluorescence of the air. A two-hours exposure with the arc source brought out faintly the cyanogen band (μ388), which is photographically the most conspicuous feature of the arc spectrum; while a three-days exposure with a quartz-mercury lamp showed only the mercury lines. Other gases were used in the vessel in place of air. With oxygen the appearance was indistinguishable from that with air, with carbon dioxide the intensity was greater than with air, and with hydrogen very faint indeed. The scattered light is almost completely polarized in the manner indicated by theory. The experiments described are preliminary to the quantitative measurements which are now in progress.—*Science Progress.*

Oxyliquite*

A Liquid Oxygen Explosive

THE present war has brought forth in Germany the industrial exploitation on a large scale of a new explosive, which but for the war would have long remained without any practical value. We mean the liquid oxygen explosive, named by the Germans "oxyliquit" or "Sprengluft" (explosive air). For convenience we shall call it *oxyliquite*.

From the beginning of the war, military necessity has compelled the German authorities to requisition the entire stock of nitric explosives. Private industries (coal mines, potassium mines, stone quarries, etc.) which used large quantities of these explosives were therefore compelled to look for some substitute. This was a favorable occasion for German engineers, who for about fifteen years had worked on the problem of oxyliquite, to give their products a trial in the industry.

Principle of the process. The principle of this explosive is entirely different from those upon which all the others are based.

Industrial or military explosives are generally substances (mixtures or definite compounds), containing two essential constituents, a combustible element, carbon, and an ignition element, oxygen. The explosion is the result of the abrupt and violent combination of these two elements.

Oxygen is introduced under the form of nitric combination (nitric ether, nitric derivatives, nitrates) or chlorinated combination (chlorates or perchlorates); carbon in form of an organic matter (cotton, phenol, toluene, etc.). It is therefore easy to see, that in ordinary explosives the combination of the active elements carries with it a considerable dead weight, constituted by the other elements (nitrogen, chlorine, potash, etc.).

It is not so with oxyliquite; here the liquefied oxygen is put in contact with carbon in a divided and porous form. Under a system of ignition, the combination takes place with explosion. We see that, in principle, the procedure is perfect. A short historical sketch of the evolution of the procedure, will show the difficulties encountered in its realization.

History. In 1895, Linde invented a cheap process for liquefying oxygen.

Immediately at Hamburg a company the "Oxyliquit Gesellschaft" was formed for the exploitation of this invention. This company began at once work upon the question of an explosive with liquid oxygen and made some laboratory research to find a suitable fuel.

In 1899, at the time of the tunnelling of the Simplon, an application of the process on a large scale was tried. Under Linde's direction two shops were built at Brieg for the liquefying of air, and from May 28 to September 12, 1899, several charges were exploded with good results. The cartridges were made of infusorial earth saturated with gasoline. The trial was not conclusive; it was discontinued as, notwithstanding the high proportion of liquid oxygen in the cartridge, the combustion was incomplete and the resulting gases, very rich in carbon dioxide were more dangerous to inhale than the dynamite gases. The face must be ventilated far longer, which sensibly retarded the work.

Later, in 1900, under the direction of a specialist, Dr. Sieder, oxyliquite was again used in the reconstruction of a bridge at Munich. More than 200 successfully exploded charges showed that the scheme was feasible. Then, nothing more is heard; the Society stopped its work, probably on account of the high price of the finished product. Since then conditions have changed, the manufacturing price of liquid oxygen has dropped, and the circumstances being otherwise favorable, the question was revived in Germany. Several societies, among them "Springluft Gesellschaft m b H (Explosive Air Society, Limited) of Berlin, the German Oxydric Aksien Ges., and the Oxyliquit Ges., of Munich, began the commercial exploitation of the liquid oxygen explosive.

According to notices in the German technical journals from 1915 to 1917, the following will show the present status of the process and the results obtained.

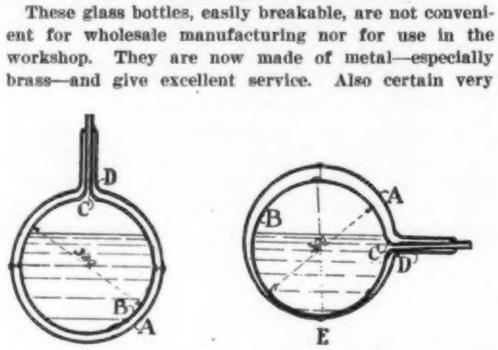
Production, transportation and conservation of liquid oxygen. Liquid oxygen is always produced on the spot where it is to be used, as it is impossible to keep it very long, notwithstanding all the precautions taken against its volatilization. It is prepared by liquefying the air, the so obtained mixture of liquefied nitrogen and oxygen, is submitted to a partial distillation, which eliminates the larger part of the nitrogen, more volatile than the oxygen. The so obtained bluish liquid contains about 85% of oxygen.

The German Society for the exploitation of the Linde patents is able to furnish installations giving an hourly output of 10 kg. (23 lbs.) of liquefied rectified oxygen. The price would be about 25 centimes per kilogram, including amortization and interest on capital invested.

To transport the liquefied oxygen from the place of production to the place of utilization, mine or quarry, a new container was necessary.

In the laboratory, glass vessels, so-called "Dewar" bottles, with double walls with a vacuum between have been used for the keeping of liquefied oxygen. These bottles are not closed—on account of the danger of a closed bottle in handling—but, thanks to the good insulation the loss of oxygen by evaporation is very small (about 50 grammes per hour, or 17.5 ozs.).

These glass bottles, easily breakable, are not convenient for wholesale manufacturing nor for use in the workshop. They are now made of metal—especially brass—and give excellent service. Also certain very



Figs. 1, 2. Bottles for transporting liquid oxygen

dense and resistent steel has been used; the walls can be made very thin, which diminishes the weight of the bottle and also its calorific capacity.

The steel or brass bottles do not hold the vacuum as well as those of glass—being more porous—and the vacuum must be often renewed. To lessen this inconvenvience, Dewar inserts between the walls very porous charcoal.

When the vacuum is made and the bottle filled, the annualar space between walls takes a temperature of —190° C. (—372° F.) the normal boiling point of the liquid, the charcoal gets extremely porous, and absorbs with great avidity the little gas that passes through the pores of the metal. The insulation power of the receptacle is well maintained for a long time. The containers, of a spherical form, which serve for the transportation, have a very slender neck in order to lessen evaporation. This slender neck would make decanting difficult, as the air which must take the place of the

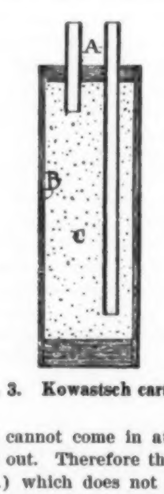


Fig. 3. Kowastsch cartridge

outflowing liquid cannot come in at the same rate of the liquid coming out. Therefore the neck of the inner Bottle B (Fig. 1.) which does not touch the external wall A, has been elongated; when the bottle is tilted, the interior tube, long and with thin walls, is bent; the inner bottle touches the outer at D and E (Fig. 2); the insulation is interrupted; there is a warming up of the space, and the warmed up liquid—partly evaporized—creates an interior pressure, which drives the liquid through the thin neck. It is thus possible to pour out quickly and steadily.

Choice of the combustible material. This must be rich in carbon, and also porous, so as to come in intimate contact with the liquid oxygen. Several have been tried; a mixture of gasoline and infusorial earth (Kieselguhr), in proportion of 40 to 60; a dry wood pulp; finely pulverized cork; dried peat; lampblack. This latter showed its unqualified superiority over all other material. It has a very constant composition, being nearly pure carbon; it has, besides, a great porosity, and possesses in a high degree the property, mentioned by Dewar, of absorbing oxygen in preference to nitrogen, when put in contact with a mixture of both liquefied gases. It is therefore possible to use liquid oxygen with 10 to 20% of nitrogen and avoid the tiresome and costly purification when wanting to get richer mixtures than 85% of oxygen. The absorption, by weights of combustible material, is about 3 times larger in lampblack than in a mixture of Kieselguhr and gasoline, drywood pulp or dried peat, and slightly less than pulverized cork; but the relative duration of the activity is about five times larger in lampblack than in the three secondly mentioned, and about equal as in the last mentioned. As for the amount of oxygen necessary for a complete combustion it ranges from 1.4 in Kieselguhr to 2.67 in lampblack and 7 to 5.7 for cork, 2.9 for wood pulp and 2.7 for dried peat. As regards the generated heat (in calories per gramme of explosives) it is highest for Kieselguhr (2300), then for lampblack (2130); pulverized cork (2000); wood pulp (1770); and least for air dried peat (1498).

PREPARATION AND METHOD OF USE OF THE CARTRIDGES

Method of Kowastsch. His is the first employed. It was perfected by the German engineer Kowastsch, with the aid of the merchant Baldus of Charlottenburg. By this process the liquid oxygen is poured upon the lampblack in the bore-hole. A cylindrical cardboard cartridge is made of the same diameter as the hole (Fig. 3); this cartridge B contains the lampblack C, or other porous material rich in carbon. It is closed at both ends with cardboard or cork. Two small tubes A, of thin cardboard, pierce the stopper at the outer end. These tubes serve for the pouring of the oxygen, also for the ignition system, (fuse or electric system). The cartridge being thus made, a metal rod is inserted in each tube to prevent them being crushed, and the cartridge is deposited at the bottom of the hole. It is then packed with a wad of clay. The metal rods are then extracted and the liquid oxygen poured in through the larger tube by means of an elbow funnel. The gaseous air escapes by the shorter tube, and also the overflow of liquid oxygen when the cartridge is saturated completely. The cartridge is now ready for the firing. The explosion is comparable to that of dynamite.

This method has its inconveniences. It often happens, that although the liquid escapes by the shorter tubes the cartridge is not fully saturated; the combustion is then not complete, the effect is lessened, and there is produced a large quantity of carbon dioxide. This difficulty of obtaining a complete or total saturation of the cartridge prevents the manufacture of cartridges larger than 0.50 m. (about 1½ ft.); and also the system of filling by small tubes prevents the placing of the cartridges in a deep bore-hole.

Method Marsit. This method is that of the Springluft Gesellschaft. It allows of a more regular working; it is therefore more in use than the other.

Here the cartridge is saturated before being introduced in the bore-hole. To do this the cartridges are immersed in a special vessel of cylindrical shape with double walls, filled with liquid oxygen (Fig. 4). The cartridges are left first exposed for a few minutes to the vapors above the liquid, to cool them off, then completely immersed for half an hour. The saturation is therefore complete.

When the cartridge is saturated, it is taken out, and the ignition system attached as quickly as possible; it is then placed in the bore-hole and tamped, as shown in Fig. 5, and exploded.

The manipulation in this method is far simpler than in the first mentioned. The only inconvenience is the unavoidable delay between the taking out of the cartridge and the placing in the bore-hole. During the lapse of these few minutes a certain part of the oxygen of the cartridge evaporates. To lessen this loss, and to keep in the lampblack a sufficient excess of oxygen, the walls of the cartridge are made watertight; they are of corrugated cardboard. Fig. 6 shows this cartridge, called the Messer cartridge, which is very much in use. This make-up explains the long duration of the immersion. But in this way the cartridges keep their strength for 8 to 10 minutes after they are taken out of the liquid oxygen.

Ignition. There is no need of a detonator to explode

* From *Le Genie Civil.*

these cartridges, and this is one of the advantages of the new method; all that is necessary is a small primer ignited by a fuse or by electricity.

The use of a fuse brings many misses: the duration and the mode of burning are largely influenced by the presence of oxygen in the bore-hole. Sometimes the fuse burns not only inside but also on the outside, especially if it is tarred or enclosed in rubber. The use of an incombustible insulation only partially remedies this inconvenience, and does not prevent the oxygen from impregnating the inner strand of the fuse and so hasten the combustion.

The electric ignition is very much superior, and gives excellent results; but not all the systems are good; those consisting of a primer filled with a mixture of gun cotton, chlorate of potash and antimony, in which is imbedded a thread of platinum, often miss fire; this is because the mass is so cold that the heated filament fails to detonate it; it often happens that the filament melts without provoking ignition. On the other hand, incandescent lighters, whose charge is fulminate of mercury or lead nitrate have given very satisfactory results, even after a prolonged immersion in liquid oxygen.

However, it must be taken into consideration, that the power of electrical transmission of platinum is very much increased by cold, so that a higher voltage must be used to obtain incandescence.

Several German inventors have devised and patented different priming systems, made of mixtures of very sensitive explosives and liquid oxygen; the primer is impregnated with oxygen at the same time as the cartridge and is ignited by the incandescence of a platinum filament.

Practical results. The use of liquid oxygen explosives has expanded in Germany, and the small difficulties encountered at the beginning are disappearing. In the potash and in the coal mines, where a breaking up explosive is needed, oxyliquite has been quickly appreciated. For this last use the composition of the cartridge has been modified so as to prevent the flame of the explosion igniting the fire-damp, or the coal dust; in order to do this either chloride of sodium (salt) or 5% water is added to the lampblack; this lowers the temperature of the flame. In stone quarries, however, the liquid oxygen explosive has not proved so successful on account of its breaking-up properties. In 1916 it was successfully used under water for the destruction of an old bridge at Marxheim on the Danube.

In order to give an idea of the extent of the use of this explosive, we mention, that the principal company manufacturing this product, the "Sprangluft Ges. m. b. H.," of Berlin, claims to have delivered each year an equivalent of 10,000 tons of nitric explosives. Even allowing for probable exaggeration, that shows how widely this product is used in Germany.

Comparison of the new explosive with the nitric explosives. The greatest advantage of the oxyliquite over all the other explosives is that it almost entirely eliminates the danger of accidents. The cartridge itself is only explosive for about 10 minutes, between the time of its saturation and the time of its ignition. During this time the danger is not any greater than with any other explosive. The result of this advantage is that in case of a miss, it is only necessary to wait half an hour for the cartridge to become entirely harmless, and so to be able to uncover the bore-hole without any danger. What is more, all danger inherent to transportation and storage of the explosive are entirely eliminated. These are indeed very great advantages.

Fig. 4. Vessel for immersion

The method, however, has its inconveniences. The principal is, that it is impossible to store liquid oxygen, therefore the need of a liquefaction and rectifying plant at the place where it is used. Also there is need of very experienced hands for a quick charging of the bore-holes.

We have said that theoretically, the new explosive is better than the others. In practice it gives an explosion hardly equivalent to the most powerful explosives known, the common dynamite and the gelatine-dynamite.

This apparent contradiction is due to the small density of liquid oxygen as it is possible to put in a bore-hole a weight far smaller than that of any other explosive. Otherwise the density of the charge of the new explosive is small; at the maximum it is 1.15 gr. per cub. cm., against 1.7 for tolyte and 1.6 for dynamite.

The density of liquid oxygen explosives varies between 0.59 and 1.15 grm. per cub. cm. as against 1.6 for dynamite and gelatine dynamite; but the heat developed, expressed in gramme-calories, compensates for the small amount of gas developed. The heat of the explosion varies between 2055 and 2056 for the first as against 1170 for dynamite and 1550 for gelatine-dynamite. The volume of gas, however, is between 298 and 598 litres per cubic cm., for liquid oxygen, as against 1,005 for dynamite and 1,136 for gelatine-dynamite. The work performed in kilogrammetres per cub. cm. is between 50.2 and 100.7 for liquid oxygen and 130.5 for dynamite and 164 for gelatine dynamite. As the quantity of energy per cub. cm. is smaller, this energy is divided over a larger area; in other words, the breaking power is smaller. Practical results have verified these conclusions. Weight for weight, however, oxyliquite may replace dynamite.

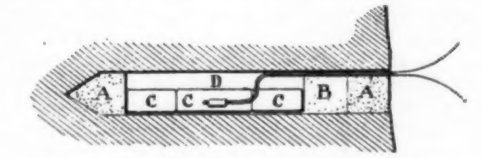


Fig. 5. Charging a bore hole

A, tampon of hard clay; *B*, tampon of soft clay; *C*, cartridges; *D*, primer and ignition fuse.

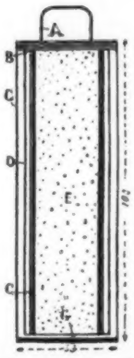


Fig. 6. Messer cartridge (Method Marsit)

A, wire handle; *B*, waterproof cardboard; *C*, waterproof paper; *D*, ordinary paper; *E*, lampblack; *G*, permeable covering.

Future of the new explosive. The question now is: will oxyliquite survive the war, which has so far favored its realization? From the standpoint of price, it is probable that, after the war, German industry will be able to produce at a very small price quantities of nitric explosives, which will probably put oxyliquite out of the market.

But the great advantages of security given by oxyliquite are not to be disdained. The suppression of the transportation of explosives by railroad and the storage of the same, the absence of danger in case of a miss, are strong reasons in its favor. What is more, as the experience acquired in handling it is getting greater every day, this method may be perfected and the price brought down to a lower level.

It is therefore not impossible that the liquid oxygen explosive will survive the war in Germany, and may probably be developed also in the Entente countries.

The Doppler Principle

In a treatise on the "Colored Light of Double Stars," published in 1842, Christian Doppler, professor of mathematics at the Technical School of Prague, enunciated the principle, that when a source of sound (or light) approached the ear (or eye), the observer would receive more waves per second than with the source at rest, and would hence have the sensation of a higher note (or of more bluish light of higher frequency). With a receding source the tone would be deeper and the light more reddish, of lower frequency. Acoustically the principle was soon verified both by placing trumpeters blowing their instruments in a moving train with the observer on the station platform, and by putting the observer in the train and the trumpeters on the platform. As regards light the enormous velocity of light seemed to exclude the possibility of an experimental verification. Studying the spectra of stars early in the 'sixties Sir William Huggins noticed, however, that the F. line of Sirius was slightly displaced to the red when compared with the same line in a hydrogen tube, and he concluded that Sirius was moving away from us.

The Doppler principle has since been applied apparently with triumphant success in many ways by astronomers and in recent years also by Stark in the study of canal rays. Such applications do not constitute any verification, however. An approximate experimental confirmation of the principle for light was first given by Belopolsky in 1901, and later, in 1907, by Galitzin and Wilip. In 1914, Ch. Fabry and H. Buisson (*Comptes Rendus*, May 25, 1914) were able to make exact measurements. Their apparatus consisted of a horizontal disc of white paper, 16 cm. in diameter, which was rotated about its vertical axis at 200 revolutions per second so as to obtain a circumferential speed of 100 m. per second. Above the disc they mounted a quartz-mercury lamp diametrically to the disc in such a way that the points A and B on the edges of the disc, being the ends of a diameter representing the projection of the lamp, were receiving light traveling at right angles to their motions. Looking very obliquely at the disc the observer saw the disc as a long elipse, with the point A as a source of light approaching him and B receding from him at high speed. With the aid of their delicate interferometer Fabry and Buisson found that the measured displacement of the interference rings was in agreement with the Doppler principle.

Last year Q. Majorana approached the interesting problem from a different point of view by devising an apparatus which demonstrated the constancy of the velocity of light reflected from a rotating mirror. If the velocity c of light of frequency n be *not* changed by being reflected from the mirror, having a velocity component v in the direction of a reflected ray, then (by Doppler's principle) the frequency n should change into $n_1 = n(1+\beta)$, where $\beta = v/c$, while the wave-length λ should change into $\lambda_1 = \lambda(1-\beta)$. If, on the other hand, the velocity of the light c be changed by the rotation of the mirror (as some physicists assert), then the new n should still have the value just given, but λ_1 should remain λ (unchanged). Majorana (*Comptes Rendus*, October 1, 1917) mounted on the circumference of a rotating wheel of 38 cm. diameter ten suitably inclined mirrors in such a way that the image from the last mirror (only four were used as a rule) travelled at 450 m. per second; observations with a Michelson interferometer showed a displacement of 0.7 or 0.8 of a fringe, when the displacement should have amounted to 0.71 fringe on the former assumption of the constancy of c.

By an elaborate similar device Majorana (*ibid.*, July 8, 1918) further demonstrated the constancy of the velocity of light emitted by a moving source. In this last apparatus two small vacuum tubes of peculiar type, containing some mercury and each provided with three electrodes, are fixed to the ends of a diameter, 2 m. long, of a rotating wheel, and receive current by brushes; two of the electrodes may be bared of the mercury in the tube by the centrifugal force. The interferometer observations agreed with the theory within 5 per cent.; the discrepancy is ascribed to experimental errors, but it might possibly be due to faulty theory. The principle of relativity is said to be confirmed by the experiments.—*Engineering.*

A Test in Acclimatization

Our exhibit of coypu rats is a good example of the possibilities of acclimatization. These large, aquatic rodents inhabit Central America and represent typical animals of the tropics. They are hardy as captives, and we determined to experiment with them under outdoor conditions during the winter. They were provided with a cement shelter house with a wooden floor and a vestibule, or similar device, to exclude the wind. These animals were abroad during the coldest days of the winter. The keepers kept the ice broken in one corner of their enclosure and the writer several times watched them diving through the small opening and remaining under the ice several minutes. Emerging from this chilling bath they would roam over the ice and nibble at the branches of willow and birch in as complacent a fashion as during warm weather. They were abroad as usual during the severe cold period[illegible] temperature registered from two to six deg[illegible]ro.—*Bulletin of the New York Zoological* [illegible]

High-Speed Internal-Combustion Engines*

Features of Design and Principles of Operation

By Harry R. Ricardo, B.A., Associate Member

In the following paper the author proposes to examine and set out some of the features of high-speed engine design, and to indicate some of the points upon which the designers of these engines have concentrated their attention. In the first place, most of these smaller high-speed engines are designed to run on petrol, and it is sometimes argued that the conditions under which they operate are totally different from those that apply to the larger and heavier types of internal-combustion engines. This is true, but to a limited extent only for, generally speaking, what applies to a petrol engine will, with certain reservations, apply equally to a gas or Diesel engine, while, so far as mechanical conditions go the problems are practically identical in either case.

The design of internal-combustion engines in this country has during the last twenty years proceeded along two widely-different lines, directed by two separate schools. On the one hand we have the designers of what may be termed the slow-speed type of engine who have consistently had to compete with, and have based their designs upon steam engine practice, and on the other hand we have the designers of small high-speed engines who have appeared with the advent of the motor car. The latter have created a school of thought of their own, and have developed along lines which are distinctly enterprising. Between these two separate schools, prior to the outbreak of war, there had been practically no interchange of ideas or experience. Each was as ignorant of what the other was doing or aiming at, as though they had been working at totally different problems. If we review the progress of both schools impartially, we find that the slow-speed school has consistently designed their engines upon sound thermo-dynamic lines, and has been influenced very largely by such able and distinguished men as Sir Dugald Clerk, Professor Hopkinson, and many others. They have, however, exhibited a decided lack of enterprise or initiative in dealing with the mechanical features. On the other hand, we find that until quite recently, at all events, the designers of the high-speed school have shown an utter indifference to the laws of thermo-dynamics, their ignorance of which has been, for the most part, profound, but they have shown a creditable degree of enterprise and imagination when dealing with the mechanical problems. It is surprising that in spite of the fact that their knowledge of the thermo-dynamic laws might in most cases be summed up as consisting of a mass of vague superstitions, they have nevertheless succeeded through a laborious process of trial and error, in producing engines whose efficiency is quite comparable with those of the low-speed school. As an illustration of the complete lack of inter-communication between the two schools, the author would cite as one example the case of the 40 horse-power Mercedes car. This car when it first appeared produced something of a sensation because its engine was really reasonably silent, at least by comparison with other engines of that date. On careful investigation, it was found that it embodied an astounding and novel feature, namely, mechanically-operated inlet valves; and yet such valves had been used as a matter of course on nearly every gas engine for at least thirty years. Again, it was not until quite recently, in fact since the outbreak of war, that the designers of the heavier slow-speed type of engine really began to awake to the vital importance of cutting down the weight of the reciprocating and rotating parts, although light moving parts have for years formed the essence of high-speed engine design.

During the course of the war the development of light high-speed engines has progressed with remarkable rapidity, and has received a very great impetus from the fact that a large number of well-trained and scientific men have devoted their attention to it, and taking advantage of the many excellent mechanical features already to be found in these designs, have also directed their development along sound scientific lines.

In answer to any imputation as to their lack of theoretical knowledge, the designers of high-speed petrol engines almost invariably used to reply with the retort that, besides being able to run at much higher piston speeds, their engines could use higher mean pressures, and showed a thermal efficiency equal to and, in some cases, relatively higher than the average gas engine. This retort was generally true, and the author proposes, before proceeding farther, to devote a short time to comparing the advantages and disadvantages of, say town gas and petrol as a fuel.

In the first instance, other things being equal, the power output of any internal-combustion engine depends upon the weight of oxygen that can be taken into the cylinder and burnt in unit time. Here petrol scores a very decided advantage for three reasons:—

1. In order to consume the whole of the oxygen present in the cylinder, the volume of petrol vapor required is only slightly over 2 per cent., while that of town gas is nearly 20 per cent., consequently the volume of oxygen in petrol is about 18 per cent. greater.

2. Owing to the latent heat of evaporation of petrol the temperature of the working fluid is reduced both before and during its entry to the cylinder. Hence a slightly-greater weight is taken in for a given volume.

3. After combustion the specific volume of the working fluid consisting of an air-petrol mixture is increased by about 4 to 5 per cent., while that of an air-gas mixture is reduced by about 3 per cent.

On these three grounds alone petrol scores heavily, for not only does the fuel itself displace less oxygen, but it also withdraws heat from the charge, and thereby increases its weight, while finally the actual volume of the charge after combustion is greater than before. But petrol labors under two serious disadvantages:

1. Owing to its very limited range of inflammability it is not possible, as with town gas, to work with a weak mixture. In fact, the mixture giving complete combustion is almost identical with that giving maximum economy, for if the mixture be weakened to any appreciable extent below that required to give complete combustion, inflammation is seriously delayed, and continues throughout the expansion stroke. As a result of this peculiarity, it is not possible by ordinary means to reduce the flame temperature, and since the efficiency of any engine, relative to the air cycle efficiency, is dependent upon flame temperature (owing both to direct loss of heat and to the change in specific heat at high temperature) it follows that from this point of view a petrol engine can only operate under the most disadvantageous conditions.

2. Owing to its low-ignition temperature and to the high proportion of hydrogen present in the fuel, it is not possible to work with so high a compression pressure. In practice the limiting compression ratio that can be used for petrol is about 5 : 1 (depending, of course, upon a number of subsidiary conditions. This gives an air-cycle efficiency of 47.5 per cent. with town gas; on the other hand, it is possible to use a compression ratio as high as 6.25:1, giving an air-cycle efficiency of 52 per cent.

These last two conditions operate in favor of gas more particularly as regards fuel efficiency.

We will consider next the case of the Diesel engine. This engine has the following advantages in its favor: 1. No fuel is taken into the cylinder until after the end of compression, hence no oxygen is displaced and the greatest possible volume is taken in. 2. The combustion of crude oil and air also results in an increase in the specific volume as in the case of petrol. 3. Additional air compressed separately is nearly always admitted to the cylinder along with the fuel. The increase in mean pressure due to the presence of this additional air is invariably credited to the indicated power of the engine. This gives the Diesel engine an apparent indicated power which is altogether illusive. In common justice, the indicated horse-power absorbed by the compressor should be deducted from that developed in the cylinder before any comparison is made between it and other internal-combustion engines.

There are so many variables connected with the Diesel cycle that the author has not attempted to show a comparative mean pressure and efficiency curve. In the first place the air-cycle efficiency itself varies with the flame temperature. Again, the proportion of air admitted along with the fuel has a powerful influence both on the mean pressure and efficiency and that proportion is a variable quantity. Thirdly, the highest mean pressure attainable is governed not so much by consideration as to the quantity of oxygen present in the cylinder, but rather by the quantity that can be brought in contact with the particles of fuel and burnt in the short time available.

From the above figures it is clear that while with petrol it is possible to obtain an indicated mean pressure of 146 lbs. per square inch under extreme conditions, or 136 lbs. per square inch under economical conditions; with town gas it is not possible to obtain a higher mean pressure than about 110 lbs. per square inch, even when working with the richest possible mixture. On the other hand with petrol it is not possible under any normal circumstances to obtain an indicated thermal efficiency of more than 33 per cent. With town gas it is possible to obtain as high an efficiency as 37.5 per cent. when working with a weak mixture and a low-flame temperature. The best modern petrol engines, such as those employed for aircraft work, do actually realize an indicated thermal efficiency of over 32 per cent. while gas engines have occasionally shown as high an efficiency as 37 per cent., showing that in both cases there is not much scope for improvement so long as the usual cycle is adhered to. It is obvious, however, that the thermal efficiency of either type of engine, and more particularly of the petrol engine, could be greatly increased by working with a lower-flame temperature; theoretically, the efficiency rises as the flame temperature is reduced until at the point of no heat supply the efficiency will equal the air-cycle, but power will be nil.

While the author has stated that owing to the very limited range of inflammability of petrol and air mixtures it is not possible by ordinary means to work with a weak mixture and hence at a lower-flame temperature, this of course applies only so long as the working fluid is homogeneous. It is interesting to consider what would happen if into a cylinder full of air there were inserted a paper bag containing a small charge of air-petrol mixture of normal density, and that at the end of compression stroke this mixture were ignited and the bag burst so that its contents, already fully aflame were discharged into the large excess of air present. Under these circumstances the effect would be equivalent to working with an extremely weak mixture, the mean flame temperature would be very low and the efficiency very high. Some such condition as this can be reproduced in a practical form by means of stratification, and the indicator diagram, taken by means of an optical indicator from one of the author's high-speed experimental engines shows the results obtained. When running under these conditions indicated thermal efficiency was no less than 38 per cent., with a mean pressure of 23 lbs. per square inch.

While comparing the two fuels, gas and petrol, there are two other points which need consideration. Petrol is a liquid and before it can be used in the engine it must be vaporized, or at least finely pulverized. This entails a certain loss, though a very small one, and it also imposes certain restrictions in the design, especially in the design of the pipework, which must be carried out in such a manner that the pulverized and partially-vaporized particles of petrol are kept in rapid and, as far as possible, continuous motion, in order to prevent them from precipitating on the walls of the pipe-work. The other peculiarity of petrol is its readiness to detonate on account of its chemical instability and of the large proportion of hydrogen present. Such detonation is generally referred to as "pinking," and often, but quite erroneously, as pre-ignition. Pre-ignition, means, of course, self-ignition of the fuel before the end of the compression stroke. Detonation, on the other hand, is merely extremely rapid burning, so rapid indeed as to cause local rises of pressure which spring the walls of the cylinder and cause them to vibrate as though they had been struck by a hammer. What actually occurs appears to be this:—A portion of the working fluid in the neighborhood of the sparking plugs is ignited and proceeds to burn in the usual manner, but so rapidly that it compresses before it the rest of the unburnt charge, until the heat of compression is such that the unburnt residue ignites spontaneously and suddenly throughout its whole bulk; in other words, flame propagation proceeds normally at first and then suddenly changes and becomes practically instantaneous. This tendency to detonate is very tiresome, and it, of course, increases as the compression ratio is increased, and the temperature and pressure of the working fluid are raised by compression. It is, as might be expected, dependent to a considerable extent upon the shape of the combustion chamber and the position of the igniter, and it also depends upon the density of the fuel; the denser the petrol the greater the tendency to detonate, presumably because the heavier fractions are chemically less stable than the lighter ones. It becomes particularly troublesome when working with paraffin. Such detonation can be kept in check in several ways:—

*From a paper before the North-East Coast Institution of Engineers and Shipbuilders (Scotland). Reported in *The Steamship*.

1. By reducing the temperature and pressure of compression by the admission of water or other such means.

2. By increasing the proportion of carbon in the fuel by mixing it with hydrocarbons of the aromatic series, such as solvent naphtha, metaxylene, or benzol.

3. By introducing inert gases, and preferably by adding gases containing carbon such as carbon dioxide; in practice this can be accomplished by readmitting cooled exhaust gases, a method frequently adopted in the case of large gas engines using coke oven gas, in which the proportion of hydrogen is large and the same trouble arises.

This tendency to detonate compels the use of a lower compression ratio than would otherwise be necessary and is a serious handicap to the petrol engine.

In modern high-speed engines every effort is made to obtain the highest possible mechanical and volumetric efficiencies, and these efforts have met with such success that the author can point to examples of quite small engines running at piston speeds as high as 1800 feet per minute, in which the mechanical efficiency is over 90 per cent., and the volumetric efficiency over 96 per cent., a result which the low-speed school have seldom, if ever, been able to achieve even with their conventional piston speed of only 800 feet per minute. One of the chief problems which the high speed engine school have dealt with in a very thorough fashion, is that of eliminating the mechanical losses, and they have certainly reduced this to a fine art.

MECHANICAL EFFICIENCY

The mechanical losses of any internal-combustion engine may be divided conveniently into three groups:— 1. The losses due to bearing friction and the driving of such auxiliaries as the valve gear, oil pumps, ignition, etc.; 2. Piston friction; 3. Fluid pumping losses.

The last of these is not, strictly speaking, a mechanical loss at all, but it is customary and very convenient to include it under this head. It is usual to specify the mechanical losses in terms of percentage of the indicated horse-power, but in the author's opinion it is preferable from many points of view, and particularly when the speed is a variable quantity, to classify them in terms of mean pressure per square inch of piston area, that is in terms of torque rather than power, so that they are directly comparable with the effective mean pressure. All the more so since it is now customary to measure the actual torque in terms of mean pressure per square inch of piston area. This is referred to as the brake mean pressure, *i. e.*, the mean pressure corresponding to the brake horse-power of the engine.

Let us consider the losses included under the first heading. These of course, are dependent to some extent upon the number of auxiliaries driven from the crankshaft, also upon the number of cylinders between which they are shared, and, to a small extent, upon the weight of the flywheel. The torque equivalent of some of these auxiliaries is dependent upon, and of others, is independent of the speed of rotation. Numerous experiments have been made in order to ascertain the extent of the losses included under this heading, and as a result they have been found to range from 1.5 lbs. per square inch mean pressure in the case of a modern 6 or 12-cylinder aero engine up to over 3 lbs. per square inch in the case of a heavy single-cylinder gas engine. As a general rule they may be taken as ranging from 2 to 2.6 lbs. per square inch for an average high-speed engine.

PISTON FRICTION

This latter is generally by far the largest item and is somewhat difficult to account for. In high-speed engines with enclosed crank chambers and forced lubrication the piston may be regarded as being practically oil borne. Compared with the main bearings, however, the average loading is very much lighter and the rubbing velocity not so very much higher. At first sight, therefore, it would appear that the friction of the piston on the cylinder walls should not be greater than that of an equivalent area of bearing surface in other parts of the engine; that it is, in fact, enormously greater is probably to be accounted for, in part by the fact that the motion of the piston is reciprocating and not continuous, and in part by the fact that the lubricating oil is always more or less contaminated and carbonized partly by the escape of a very small quantity of burning gases past the piston rings, and partly by the exposure of the cylinder walls to the high temperature of combustion which tends to carbonize the film of the oil adhering to them. As a result of this contamination the viscosity of the oil is increased enormously, and, therefore, also its resistance to shear. A very large number of experiments have been carried out by the author and others in order to determine both the cause and extent of piston friction in gas and petrol engines. Briefly it seems that the main causes are those stated above, and that the extent is almost directly proportional to the average thrust on the cylinder walls and indirectly proportional to the rubbing velocity and the area of surface.

FLUID PUMPING LOSSES

The extent of these losses depends very largely upon the form of pipework, and upon the velocity through the piping and valves. Provided that the pipework, and particularly the intake pipe, is reasonably short, *i. e.*, not more than 8 diameters, and that the internal diameter is not less than that of the valve port, also that the valve timing is more or less normal, the loss due to fluid pumping may be taken as dependent upon the velocity through the valve ports, and is approximately as shown in a diagram, in which the horizontal scale denotes the average gas velocity through the valve ports based on the assumption that the valve is fully open throughout the stroke, and the vertical scale denotes the mean pressure of the suction-exhaust loop. This curve has been prepared from a very large number of indicator diagrams and from motoring tests, and may be taken as being substantially correct and applicable to any class of four-cycle engine.

It is interesting to compare the mechanical losses of three actual engines each of about 80 horsepower per cylinder:—

1. A Diesel engine bore 16.0 inches, stroke 19.0 inches, normal speed 250 revolutions per minute. Piston speed 790 feet per minute. Weight of reciprocating mass 994 lbs. Mean gas velocity through valves 150 feet per second.

2. A gas-engine bore 15.0 inches, stroke 24.0 inches, normal speed 200 revolutions per minute. Piston speed 800 feet per minute. Weight of reciprocating mass 655 lbs. Mean gas velocity through valves 130 feet per second.

3. A petrol-engine bore 7.25 inches, stroke 8.5 inches, normal speed 1400 revolutions per minute. Piston speed 1980 feet per minute. Gas velocity through valves 130 feet per second. Weight of reciprocating mass 11.35 lbs.

Bearing, etc.	3.5	3.0	1.8
Piston friction	11.8	7.8	7.2
Fluid pumping loss.	4.5	3.4	3.4
Total	19.8	14.2	12.4
Brake mean pressure	75	75.0	118.0
Mechanical efficiency.	79%	84%	90.6%

In these figures in order to make them truly comparative no account is taken of the air compressor usually fitted to Diesel engines. The indicated mean pressure is taken as 89.0 lbs. per square inch in the gas engine and 130.0 lbs. per square inch in the petrol engine.

It may be argued that while the mean pressure taken in the case of the petrol engine is very nearly the maximum obtainable, that taken in the case of both the gas and Diesel engine is well below the maximum, and that, therefore, the comparison is not a just one. The answer to this is that in both the gas and Diesel engines the cylinder bore is so large that it is not possible to work with higher mean pressures owing to the excessive heat gradient across the piston and through the walls of the combustion chamber. In the petrol engine, however, with its small cylinder and thin walls, it is possible to dispose of the heat, and that with the same, or even a smaller, temperature difference between the inside and outside of the cylinder walls and combustion head. Again, in the petrol engine the mean pressure can only be cut down by throttling the charge as already explained, and not be reducing the mixture strength.

VOLUMETRIC EFFICIENCY

It is, of course, obvious that to obtain the best results from any type of internal-combustion engine every effort must be made to obtain the highest possible volumetric efficiency, but at the same time it is also of vital importance that the working fluid shall be in a state of the utmost possible turbulence in order to spread and distribute the ignition. This applies with equal, if not with greater, force to Diesel engines in which the necessary intimate contact of the particles of fuel and air is brought about quite as much by the turbulence of the air within the cylinder as by the spraying of the fuel. In the author's experience, provided that the air in the combustion chamber can be maintained in a state of violent commotion, excellent combustion can be obtained even with very indifferent spraying. The necessary turbulence can be obtained in most cases only by admitting the gas at a high velocity through the inlet valve. The problem, therefore, resolves itself into one of obtaining the highest possible velocity through the valve with the least possible wire drawing, *i. e.*, the nozzle co-efficient of the valve opening regarded as an orifice, must be as high as possible. Provided that the valve and its passages are designed to give the highest orifice co-efficient, the author has found that the best all-around results are obtained when the velocity through the inlet valve is in the neighborhood of 130 feet per second. With carefully-designed valve passages and no further restriction or change of direction after the gases have passed the valve, it is possible with this velocity to obtain a volumetric efficiency within 3 per cent. of the maximum possible figure, while the degree of turbulence is sufficient to give within two or three per cent. of the highest possible efficiency, *i. e.*, any lower velocity through the valves results in an appreciable drop in the efficiency and power output due to insufficient turbulence, while any higher velocity results in loss of volumetric efficiency due to wire drawing.

It can be proved that if the swept volume of the cylinder is completely filled with working fluid at atmospheric pressure the volumetric efficiency in terms of standard pressure and temperature will be approximately 82.7 per cent. of the swept volume.

PISTON DESIGN

Of the individual mechanical features of high-speed engines by far the most important is the design of the piston, for not only does piston friction constitute the bulk of all the mechanical losses, but the weight of the piston itself is responsible for a very large part of the load on the bearings and for the stresses in the engine structure due to opposing couples. The design of the piston must be carried out with a view to:—

1. *Dissipating Heat.*—This is met by the use of copper aluminum alloys, whose conductivity is about four times that of cast iron.

2. *Reducing Weight.*—This, of course, is a question of suitable distribution of the material so that the loads are transmitted as directly as possible from the crown of the piston to the connecting rod and from the connecting rod to the cylinder wall.

3. Reducing as far as possible the area of surface in contact with the cylinder walls, *i. e.*, cutting down bearing surface where it is not required.

4. Preventing distortion.

The conventional design of trunk piston as used in most single-acting slow-speed internal-combustion engines is probably about as unimaginative and as defective as it could be. In the first place, the dissipation of heat is catered for by the simple but unenterprising method of piling on masses of metal instead of by attempting to employ a material with a higher conductivity. In the second place, the whole of the pressure from the crown is transmitted through the side walls of the piston and thence to the two extreme ends of the gudgeon pin, with the result that these walls have to be abnormally thick; heavy gudgeon-pin bosses must be employed which result in distortion, and finally the deflection of the gudgeon pin sets up a further distortion of the piston and gives rise to trouble with the gudgeon-pin bearing. It is usual also in slow-speed engine practice to make the whole length and circumference of the piston below the piston rings bear against the cylinder walls, though much of this area is useless as bearing surface, and merely serves to increase piston friction. In high-speed engine design, however, every effort is made to reduce the weight and friction, on the one hand by cutting down the weight and bearing surface of the conventional design to the furthest possible limit, and more recently by departing from the more conventional form.

GUDGEON PINS

In nearly all large internal-combustion engines the gudgeon pin and its bearing are a source of more or less anxiety. In small high-speed engines, however, this pin and its bearings seldom, if ever, give the slightest trouble. The main reasons for trouble in large engines appear to be:—1. Distortion of the piston; 2. Bending of the gudgeon pin; 3. Severe average loading due to the heavy inertia forces.

Of these by far the most important is the bending of the gudgeon pin due to the fact that the load from the piston crown is delivered to it at its extreme ends, and is taken more or less from the center. The author has found that by using a very short gudgeon pin and delivering the load to it at points as close to the center as the connecting-rod small end bearing will allow, it is possible to employ a very much smaller bearing surface than usual, and that with considerably less wear than with the conventional long gudgeon pin and very wide connecting-rod bearings. Further, the wear that takes place on the gudgeon pin owing to the small arc through which the connecting rod rocks is very local, and, therefore, cannot be effectively corrected by rebushing the connecting-rod or taking up the bearing.

BEARING PRESSURES

The life and safety of a well-lubricated bearing may be assumed to be dependent upon the average load factor on that bearing, and by load factor is meant, the average load multiplied by some function of the rubbing velocity, for it is this factor which controls the temperature of the bearing, and the viscosity of the lubricant. When dealing with high-speed engines the author employs for comparative purposes a load factor made up of the product of the mean average loading and the rubbing velocity. This factor, however, cannot fairly be used to compare engines of widely-different speeds, because it clearly lays too much stress on the rubbing velocity, but it is useful as a comparison as between various high-speed engines. In calculating the load factor, it does not matter in the least in what direction the load is applied, whether it is continuous or frequently reversed, provided always that the lubricant can be constantly maintained and replenished. The maximum pressures since they are applied for so short a time may be ignored provided that they are not sufficient to crush the bearing material or seriously distort the journal. Now in a high-speed engine the bulk of the loading on say the connecting-rod big-end bearing is due to centrifugal force, and the inertia of the reciprocating mass, the average loading due to fluid pressures is relatively small. Again the bulk of the loading on most of the crankshaft main bearings is due to centrifugal pressure set up by the crank-pins, crank-webs, and connecting-rod big-end bearings. By concentrating attention upon reducing the weight of both the reciprocating and rotating parts the average bearing loadings can be reduced to a remarkable extent, and it is mainly upon the extent to which these parts have been lightened that the success of the high-speed internal-combustion engine depends. It should be noted that the weight of the rotating mass is largely dependent upon that of the reciprocating mass, for it is this which governs the strength and size of the connecting-rod bolts, the bosses for which constitute a very large proportion of the rotating weights.

COMPARATIVE WEAR AND TEAR OF SLOW AND HIGH-SPEED ENGINES

In both high and slow-speed engines the general wear and tear may be measured in terms of the bearing wear, for it may be assumed that the life of the other working parts is at least proportional to that of the bearings. Assuming that the system and supply of lubrication is the same in both cases, the wear may be taken as being proportional to the product of the mean average loading on the bearings and some function of the rubbing velocity, probably about the square root. It is interesting, therefore, to compare the average load on say the connecting-rod big-end bearing of a Diesel engine, a gas engine and a high-speed petrol engine, all of about 80 horse-power per cylinder, the Diesel engine running at 250 revolutions per minute, the gas engine at 200 revolutions per minute, and the petrol engine at 1400 revolutions per minute. The projected area of the crank-pins in the three examples are:—Diesel engine, 94.3 square inches; gas engine, 45.1 square inches; petrol engine, 11.4 square inches.

The average loading on the crank-pin bearing is made up of:—1, the actual fluid pressure in the cylinder; 2, the inertia pressure due to the reciprocating masses; 3, the centrifugal loading due to the weight of the rotating portion of the connecting-rod.

These are not all cumulative, but when the necessary corrections have been made, the average loading will be the same when the Diesel engine is running at 360 revolutions per minute, the gas engine at 250 revolutions per minute, and the petrol engine at 1370 revolutions per minute.

It might be argued that the life and durability of any engine depends upon other parts than the bearings, such for example as the exhaust valves and the valve gear generally. In modern high-speed engines, however, provided that the valve gear is properly designed and that multiple valves are used when either the stresses in the gear or the heat flow become excessive, and provided also that the exhaust valves are seated directly on to water-cooled seatings and not, as is sometimes the case, in detachable housings, then trouble with valves is of rare occurrence. Exhaust valves nowadays generally require grinding after about the same number of hours running in either high-speed or low-speed engines, and breakages have become things of the past.

The question of balancing and the elimination of vibration is, of course, a vital one, particularly in small high-speed engines most of which are generally fitted to light structures, such as motor cars and aeroplanes. In such cases it is customary to employ four or more cylinders. With four cylinders and cranks at 180 degs. all the primary forces are balanced and the couples formed by each pair of pistons are opposed to one another so that they exert a bending moment on the structure of the engine but cause no external disturbance. In very high-speed engines it is found that the unbalanced secondary forces due to the angularity of the connecting rods cause a serious disturbance.

There is yet another and frequently very troublesome source of vibration in six-cylinder engines, namely, torsional vibration of the crankshaft. This is due to the fact that the end of the shaft furthest from the flywheel is, so to speak, wound up when the maximum turning moment is applied to it and released when the pressure is released. At certain speeds this alternate winding up and release coincides with the natural period of the crankshaft, with the result that the shaft vibrates excessively and the reciprocating masses which are attached to it vibrate with it and impart their vibration to the whole structure. Such torsional vibration can be prevented almost entirely by the use of the "Lanchester" damper, which consists of a small flywheel mounted loosely on the crankshaft and connected to it through the medium of a friction clutch. The flywheel rotates at a constant angular velocity, and any relative movement of the end of the crankshaft results in the slipping of the clutch. The damper does not prevent the crankshaft from being wound up and released, but it does effectively prevent it from continuing in a state of vibration. This damper has proved most effective on high-speed engines, and one has recently, at the author's advice, been fitted to a large slow-speed six-cylinder Diesel engine in which torsional vibration of the crankshaft had proved so troublesome that the engine could not be used. Since fitting the damper this trouble has entirely disappeared, and the engine is now running quite satisfactorily.

In the foregoing remarks the author has endeavored to show that the modern high-speed internal-combustion engine can compare quite favorably with the heavier slow-speed type as regards durability and relative fuel consumption while its advantages as regards weight and space occupied are, of course, undeniable. There is, however, an impression prevalent that these small high-speed engines require a standard of workmanship, and the use of material that can only be obtained at such a cost as to render them almost as expensive as the heavier slow-speed type. This is certainly not the case. First, as regards workmanship, it is true that a high standard of accuracy is required, and above all the alignment of the engine must be beyond suspicion, but the accurate manufacture of small parts need not be expensive, provided that they are made in large enough quantities, indeed the experience of the last four years has served to show that a high standard of accuracy can be attained commercially without any appreciable increase of cost. With regard to materials, it is not in the least necessary to provide any fancy or costly materials. Crankshafts made from 0.35 carbon steel, oil-toughened, are found to be perfectly satisfactory. For the valves, 3 or 5 per cent. nickel steel gives excellent results if case-hardened, and for the pistons an alloy consisting of 88 per cent. aluminum and 12 per cent. copper is probably about the best. This alloy has the advantage that is it easily prepared and easily cast, and it is also suitable for die-casting. The rest of the engine can be made from the same materials as are employed in the slow-speed type. During the course of the present war the high-speed engine has come into its own and has developed in a most astonishing manner, the daily output of this country alone exceeding 30,000 h. p.

In conclusion the author must apologize for having dealt at length with only one feature of mechanical design, namely, the design of piston. Unfortunately, the time available does not permit of dealing with many other almost equally interesting features such as the design of valve gear and cylinder construction.

A New Waterproof Oil

A NEW French waterproof oil is prepared by mixing 100 parts of castor oil with 200 of amyl acetate, and stirring up with 25 parts of sulphur chloride. The mixture soon assumes the form of a fairly solid jelly, giving off much hydrochloric acid, but if enclosed several days in a tight vessel, it becomes completely liquefied. Neutralizing the acid with barium carbonate and filtering now yields an almost colorless solution of the vulcanized oil. This solution is adapted for waterproofing cloth, leather, paper, etc., or, mixed with such other solvent as alcohol or benzine, it may be made to dissolve sufficient nitro-cellulose to produce a resistant varnish for glossy leather or oilcloth. With suitable pigments, the varnish forms a waterproof, quick-drying paint.

Wireless Receiver in German Aircraft

As is well known, German dirigibles are equipped with wireless telegraphic apparatus, but there has always been a certain amount of speculation as to how the scarcely perceptible signals can be heard in the midst of the noise due to the motors and the displacement of the air. According to a German technical publication quoted in *La Nature*, a special method is in use. The high frequency oscillations of the receiving station act on an Einthoven galvanometer. The plant recalls the prismatic sight. Underneath is a small electric lamp, the light of which falls on a narrow slit, ordinarily covered by the galvanometer string. The string is in an intense magnetic field. When the receiving current passes, the string deviates, thus allowing the luminous ray to be perceived. The observer at the sighting device can thus read the signals transmitted, in dots and dashes, in the form of short or long light-rays projected by the illuminated slit.

SCIENTIFIC AMERICAN SUPPLEMENT

Founded 1876

NEW YORK, SATURDAY, OCTOBER 26, 1918

Published weekly by Munn & Company, Incorporated
Charles Allen Munn, President; Orson D. Munn, Treasurer
at 233 Broadway, New York.

The Scientific American Publications

Scientific American Supplement (established 1876) per year $5.00
Scientific American (established 1845) 4.00

The combined subscription rates and rates to foreign countries including Canada, will be furnished upon application.

Remit by postal or express money order, bank draft or check

Munn & Co., Inc., 233 Broadway, New York

The purpose of the Supplement is to publish the more important announcements of distinguished technologists, to digest significant articles that appear in European publications, and altogether to reflect the most advanced thought in science and industry throughout the world.

Back Numbers of the Scientific American Supplement

SUPPLEMENTS bearing a date earlier than January 1st, 1918, can be supplied by the H. W. Wilson Company, 958-964 University Ave., Bronx, New York, N. Y. Please order such back numbers form the Wilson Company. Supplements for January 1st, 1918, and subsequent issues can be supplied at 10 cents each by Munn & Co., Inc., 233 Broadway, New York.

Table of Contents

6, 1918

ft

ed with
ys been
scarcely
he noise
the air.
noted in
igh fre-
on an
e pris-
mp, the
covered
intense
ces, the
to be
an thus
in the
illumi-

AN

1918
ed
reasurer

r $5.00
. 4.00
ountries
n.
heck
York

ublish
listin-
arti-
, and
hought

an

nuary
Com-
N. Y.
Com-
subse-
Munn

re in a
branch
posed
thor-
nt ap-
of the
nical,

, who
rk ap-
United

s,
vay,
N. Y